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ABSTRACT

The problem of productivity and its impact on manufacturing engineering is the main focus of a program designed to develop a university-industry relationship that will provide professional training to students and input into the manufacturing industry. The current status of existing university-industry interaction at the foreign and domestic levels and cooperative programs are discussed as well as other tasks to be completed by the program. A paper reviewing the proposed engineering internship program is included with supporting charts. The program centers on industry, student, and university characteristics and their interrelationships. The major part of the document (63 pages) consists of two reports on visits abroad (Germany, and Japan and Korea) to study aspects of university--industry interaction. The report on Germany describes the institutions visited, contacts established, and the types of activities observed. It provides an in-depth description of engineering education and research at the university with emphasis on manufacturing. The report on Japan and Korea is presented in three parts: (1) information on engineering education in Japan, (2) individual reports on specific visits in Japan, and (3) information on technical education and research in Korea. A 45-page section presents three reports on symposia conducted and attended as part of the program. (Author/EC)

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INTERIM REPORT
ON TASK "A"
OF AN
EXPERIMENT IN MATERIALS PROCESSING ENGINEERING EDUCATION:
THE INDUSTRIAL INTERNSHIP PROGRAM

Submitted to the National Science Foundation
under the
Experimental R & D Incentives Program
on Human Resources for Technology Innovation

by

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U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

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CE007099

The Department of Mechanical Engineering and
Engineering Mechanics, Michigan Technological University
Houghton, Michigan
March 15, 1974

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1. INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

The Proposal "Experiment in Materials Processing Engineering Education: The Industrial Internship Program" (1) was prompted by the problems of a "productivity crisis" that was seen to exist at the time of its writing: a severe balance of payments deficit with a balance of trade deficit as one of its most noticeable components. The blame for these developments was generally placed on a level of productivity significantly below that of a number of foreign competitors on the world markets (2). Within one year events took place which appear to have shuffled national priorities. For one, the U.S. currently enjoys a trade surplus, brought about by currency realignments. Secondly, the Yom Kippur War at long last has jolted the industrialized world into the realization that the earth's non-replenishable resources are in fact finite in quantity, and supply levels of some of these are growing dangerously low. The word "Energy Crisis" suddenly became the word of the day, although "Materials Crisis" would have been a more appropriate choice. Did national priorities really change since a year ago? The answer is suggested by a brief review of the definition of Productivity. Simply put, productivity is the measure of output for a given amount of human effort. But Mr. R.C.Gerstenberg, President of the General Motors Corporation, goes further in his definition of productivity:

> Productivity is a measure of management's efficiency, or lack of efficiency, in employing all the necessary resources--natural, human, financial. (2)

Similarly, L. L. Lederman, Director of the National Research and

Development Assessment Program of NSF, states

> Productivity is the relationship of output to associated inputs, in 'real,' physical volume terms. Thus, changes in the ratio of output to input measure changes in the efficiency with which inputs of scarce resources are converted into goods and services. (2)

It is thus clear that productivity had been a measure of efficient use of our natural resources all along, even before the nation became painfully aware of the Energy Crisis. Thus, national priorities clearly have not changed.

The problem of productivity remains very much at the core of any solution to the materials shortage problem. It thus appears that the objectives of this proposal and the proposal itself have remained very much relevant to our present problems.

The United States will need more and better qualified technological entrepreneurs and innovators to tackle these problems and those looming on the horizon. Invigorated interaction between the industrial and academic communities, as promoted by the Internship Program, can be an important factor in the solution to the productivity problem.

1.2 OBJECTIVES

Under the Experimental R & D Incentives Program of the National Science Foundation, Michigan Technological University proposes an experiment with the objectives to

1. Provide professional training in an atmosphere of innovation for students planning to enter manufacturing engineering.
2. Develop and maintain a university-industry relationship conducive to joint activities that will lead to increased transfer of new manufacturing technology to the manufacturing industry and will provide feedback to the educational system of the university.

It is proposed that these objectives can be achieved through an educational program which brings together a student or students, a university faculty member, and an engineer from industry to form a team. It is the task of this team to solve an engineering problem provided by industry. Details on the program are provided in Chapter 2 as well as in Reference (1).

Specifically, the purpose of this phase of the project is to

- review existing university-industry interaction, domestic and foreign, involving public, private and captive institutions
- conduct symposia for potential industrial participants
- identify interested companies and students
- establish an advisory council
- conduct meetings for faculty and industrial participants to establish program objectives, procedures and guidelines
- and to design the full experiment.

1.3 CURRENT STATUS OF THE INVESTIGATION

Existing University-Industry Interaction--Foreign. During the Manufacturing Productivity Conference held in October, 1972, in Washington, D. C. (2), Germany and Japan were frequently mentioned as nations enjoying high productivity and strong government backing in their R & D efforts. Consequently, it was felt that these countries should be visited to gain first-hand information, also with regard to university-industry interaction there. Reports on these trips comprise Chapter 3 of this report. The experiences in Germany turned out to be of particular value, since a very strong working relationship exists between universities and industry in that country. The potential benefits of applying some of the practices observed to the U.S. system are worthy of investigation.

Written inquiries went out to universities of other European countries to obtain corresponding data. Not all requests for information have been honored yet, so these findings will be included in the final report. It can be stated, however, that the same type of university-industry interaction exists in all Central European countries (Germany, Switzerland, Austria and its former dependencies), as evidenced by the fact that Austrian and Swiss companies do join German companies in cooperative research ventures involving German universities, for example.

Existing University-Industry Interaction--Domestic. Aside from interaction that frequently exists between an individual professor and industry, a number of schools have been identified which have established systematic programs aimed at a more productive interchange between university and industry.

One type of program found at a number of universities is intended to cultivate a mutually beneficial partnership between industry on one hand and university administration and professors on the other. Michigan Tech's Corporate Associates Program and M.I.T.'s Associates Program and Industrial Liaison Program belong in this category. Member firms gain access to the educational and research programs of the school, and the school receives financial support. Some of the means of communication are individual visits on campus or in industry, different types of publications on research activities at the school mailed out to member firms, seminars, colloquia, and round table meetings to promote exchange of professional experience and information. The programs of M.I.T. involve on-campus representatives who are responsibile for establishing contacts in areas of coincident interests with member companies, and thus for developing effective relationships between these firms and the school.

On a visit to the University of Michigan, it was learned that this school, recognizing the importance of computer-aided design and manufacturing (CAD/CAM) for industrial production, has instituted the Industry-University Consortium Research Program on Computer-Aided Manufacturing. The Mechanical Engineering Department and an industrial Technical Advisory Committee are exploring ways for increasing university involvement in CAD/CAM. As a result the U. of M. is now active in research and teaching in this field.

The Processing Research Institute of Carnegie-Mellon University offers a Master of Engineering Program designed to prepare graduate students professionally for engineering careers. Students are given industrial projects, and they have the major responsibility for their successful completion. Each project is directly supervised by PRI faculty members, but also receives direct input from engineering experts from industry. Currently, about 15 companies are participating in the program. The working arrangement with each firm provides for project funding to be shared equally by the company and NSF for the first year. Subsequently, the company carries all project costs. The cooperation of the Departments of Chemical Engineering, Mechanical Engineering, and Metallurgy and Materials Science makes this program interdisciplinary.

Co-op Programs. Colleges and universities across the United States and Canada are adopting Co-op Programs at an accelerating rate. Cooperative education in its standard form has the following features (3,4): By placing an interested student into industry according to a time schedule convenient to him, he gains industrial experience to supplement his classroom learning. The student customarily enters the program after completion of his first year in college. Care is taken in trying to match the student's field of study and his work assignment. The level of these assignments is adjusted to conform to the student's academic progress, i.e., he assumes increasing responsibility as he nears graduation. The student's work experience becomes part of his formal education, and he receives academic credit for it. His academic studies become more relevant to him, as he is able to relate theoretical learning to his job experience.

In summary, three different types of university-industry interaction in the U.S. have been identified so far:

1. Industry deals directly with professors in order to bene-

fit from the research potential of the university. Students are not involved on a systematic basis, although graduate students will usually be active in related research efforts. The flow of technical information tends to be directed from the university to industry. Some feedback from the research effort to the classroom exists.

2. A number of students (undergraduate) gain industrial experience, and thus are the primary beneficiaries of the interchange. No direct involvement by the universities exists to benefit industry, and there is practically no feedback from industry to the university which would be helpful to make teaching more relevant to all students.
3. A number of students (undergraduate and graduate) gain industrial experience by working with faculty members and practicing engineers on an industrial problem. All parties involved in the project benefit: the student gains valuable experience, the company gets a problem solved with the help of the university, and the faculty member gains practical experience. Communication channels between university and industry are open, and the flow of information from industry to the university makes engineering courses more relevant so that all students taking these courses benefit.

Of course it should be emphasized that these classifications need not be as rigid as outlined here. Instead, a wide spectrum of combinations or variations of these program types is possible, subject to the ingenuity and needs of the program participants.

Symposia on University-Industry Interaction. In recent months a number of symposia were held which dealt with the need to improve university-industry interaction and the transfer of technology.

In December of 1973, Carnegie-Mellon University conducted the NSF-sponsored "Workshop on Research and Educational Needs in the Pressure Vessel Piping and Related Industries," which was intended to advance university-industry interchange. A brief description of this meeting is included in Chapter 4.

Also in December of 1973, M.I.T. held the "National Conference on Manufacturing Technology and Productivity." A detailed report on the proceedings of this meeting is included in Chapter 4.

Michigan Tech held NSF-sponsored symposia on December 12, 1973, in Dearborn, Michigan, and on March 1, 1974, on the Michigan Tech campus. The purpose of these events was to advertise the proposed program to industry and to stimulate discussion on it. It was felt that early input by industry would aid in the final design of the experiment. Proceedings of these meetings are included in Chapter 4.

Some of the significant results of these meetings are:

The industrial representatives agree that the program proposed by Michigan Tech is very promising. Although it shares a common feature with the co-op program, namely, the practical experience gained by the student, its involvement of university faculty makes it most appealing to them. They feel that channels of communication, which would thus be opened between university and industry, benefit all participants. Better than 80 percent recommend that their companies participate in this program. Additional details, shown in Chapter 4, include the results of a questionnaire responded to by industrial participants of the symposia.

Status of Industrial Commitments and Advisory Council. There appears to be little difficulty in finding companies willing to participate in the program. Presently, companies from whom positive responses have been received can be categorized as: a) committed to the program, b) expected to make a commitment, and c) having expressed an interest as shown:

Companies Committed to the Program

Deere & Company, Moline, Illinois
Grede Foundries, Iron Mountain, Michigan and Milwaukee, Wisconsin
Ford Motor Company, Chassis Division, Dearborn, Michigan
Concord Manufacturing Company, Concord, Michigan

Companies Expected to Commit Themselves to the Program

Caterpillar Tractor Company, Peoria, Illinois
Garden Way Manufacturing Company, Troy, New York
Union Carbide Corporation, Buffalo, New York
Sagniaw Steering Gear Div. of General Motors, Saginaw, Michigan
Motor Wheel Corporation, Lansing, Michigan
Steel Case, Inc., Grand Rapids, Michigan
Dow Chemical Company, Midland, Michigan

Companies Having Expressed an Interest in the Program

Besser Company, Alpena, Michigan
Bucyrus Erie Company, S. Milwaukee, Wisconsin
Cleveland Cliffs Iron Company, Munising, Michigan
Giddings & Lewis Machine Tool Company, Fond du Lac, Wisconsin
D. A. MacPherson, Inc., Iron River, Michigan
Lear Siegler, Inc., Detroit, Michigan
Scott Paper Company, Oconto Falls, Wisconsin
White Pine Copper Company, White Pine, Michigan

ADVISORY COUNCIL FOR PROJECT

1. Robert M. Colton, Project Director,
   Private Sector, ERDIO, NSF

2. Richard O. Lane, Director of Marketing,
   Frank Bancroft Co., Inc., Dearborn, Michigan

3. Gerald T. Underwood
   Mgr. of Personnel and Management Development
   Deere & Company, Moline, Illinois

4. Marvin F. DeVries, Associate Professor
   Department of Mechanical Engineering
   University of Wisconsin, Madison

5. Henry Gregorich, Chief Engineer,
   Product Engineering Office, Chassis Division,
   Ford Motor Company, Dearborn, Michigan

6. L. J. Woelke, President,
   Grede Foundries, Inc., Milwaukee, Wisconsin

1.4 REMAINING TASKS

A number of tasks remain to be completed. These are:

Complete study of domestic university-industry interaction. Efforts to make a more complete assessment of university-industry interaction in the U.S. will be continued. The search will concentrate on programs which deviate from conventional co-op education, since its scope has been clearly identified, as described in the previous section.

Finalize the list of participating "players" for the first year. It is recognized that the "players" will increase in number and may vary over the next years, as the program grows. At first arrangements must be finalized with the companies which will help to start up the program. This includes establishing projects and the teams (student-professor-practicing engineer) that will be responsible for their successful completion. At the same time industrial participants must be identified for subsequent years.

Meetings for faculty and industrial participants will be held to establish program objectives, procedures, and guidelines. Formation of teams also requires the identification of interested as well as qualified students. This task will be undertaken in the very near future.

Final design of the experiment. The input provided by the symposia and the faculty/industry meetings will be helpful in the final design of the experiment. Since a major part of the experiment is its evaluation, criteria and techniques will be outlined to help determine the success of the program. It has come to our attention that cost/benefit studies are being conducted by two universities on the effects of co-op education. These schools will be contacted in an attempt to determine what their experiences are and what suggestions they may have for a meaningful analysis of a program such as the one proposed.

List of References

1. Weinmann, K. J., J. C. Gerdeen, and G. L. Scofield, "A Preliminary Proposal on an Experiment in Materials Processing Engineering Education: The Industrial Internship Program," Revised, submitted to the National Science Foundation under the Experimental R & D Incentives Program on Human Resources for Technology Innovation, March 12, 1973.

2. Proceedings of the Manufacturing Productivity Conference, sponsored by SME, NSF, and NBS, Washington, D.C., October 11-13, 1972.

3. United States Civil Service Commission - Chicago Region - The College Newsletter, January, 1973, Special Edition.

4. "Fifty Views of Cooperative Education," A compilation of the notes of the faculties of the several Institutes on Cooperative Education Administration conducted during 1972-73 under a Title V-E, EPDA, Grant from the U.S. Office of Education, Bureau of Higher Education, by Donald C. Hunt, Director of Cooperative Education, University of Detroit.

2. REVIEW OF THE PROPOSED INTERNSHIP PROGRAM

THE ENGINEERING INTERNSHIP PROGRAM

by

J. C. Gerdeen

Problems

The Engineering Internship Program has been prompted by problems of manufacturing productivity, foreign trade unbalance, and related causes such as technology transfer, lack of research and innovation and technology gaps of one sort or another. For example, during the first quarter of 1972, the U. S. experienced a foreign trade unbalance of 1½ billion dollars. This has been artificially offset during 1973 by the devaluation of the dollar, but the real cause of this problem still exists. The Engineering Joint Council [1] foresaw this problem when they said:

> Minimal U. S. support of industrial research may lead to a loss of technological world leadership in civilian markets.
>
> Closer collaboration between engineering and educational theorists, should be encouraged, especially in universities having strong schools of engineering.

The cause of this foreign trade unbalance may relate back to the amount of research effort in manufacturing processes. In metalworking research the U. S. has been outdone by Japan and Western Europe as Table 1 shows. Japan has expended about two times as much research effort and Europe more than four times as much. It is not surprising then that the U. S. faces serious competition from these countries in manufacturing productivity.

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[1]"The Nation's Engineering Research Needs 1965-1985," EJC, January 1963.

If research and development are important to increased productivity, it is worthwhile to consider the innovation process and blockages therein. Table 2 shows the basic elements of the innovation process. Blockages exist between these elements. There are several of these, but the technical and educational will be considered as the important ones here.

There is a technology gap. Where is it? A recent survey, Table 3, showed that a technology gap exists in the material processing area. For example, tools and dies for metal forming are designed by experienced artisans. A new design requires a trial and error approach. Yet, the technology exists to make this art more of a science, and thus save lead time and avoid unnecessary development expenses.

Table 4 shows that there is also a lack of educational background of manufacturing engineers. As indicated on the previously cited Table, Table 2, the NSF R & D incentives program has as its objective to overcome these technological and educational blockages in the innovation process.

The Internship Program

Manufacturing productivity involves industry. A technological education involves a student and the university. These three identities are shown in Figure 1. Very often, and unfortunately, two of these identities, the industry and the university exist by themselves with some distaste for each other. The industry may

TABLE 1
ANNUAL RESEARCH EFFORT IN METAL WORKING (1963)

	United States		Japan		Europe	
	Man Months	%	Man Months	%	Man Months	%
New Metal Removal Processes	229	15.6	323	12.3	516	9.4
Existing Metal Removal Processes	424	28.8	1575	59.7	2033	37.1
New Metal Forming Processes	439	29.8	63.6	2.4	502	9.1
Existing Metal Forming Processes	---	----	---	----	---	----
TOTALS	1470		2635		5942	

TABLE 2

PROBLEMS: EMPLOYMENT, INFLATION, "PRODUCTIVITY," TRADE BALANCE, ECONOMY.

R&D Productivity

INNOVATION PROCESS: Basic Research
↓
Applied Research & Development
↓
Design & Engineering
↓
Production
↓
Marketing

Iterations:

"BLOCKAGES" IN THE INNOVATION PROCESS:

- FINANCIAL
- TECHNICAL
- INFORMATIONAL
- MARKETING
- EDUCATIONAL
- LABOR

RESEARCH INCENTIVES PROGRAM: Support "experiments" to test federal incentives in overcoming blockages in the innovation process.

TABLE 3

WHERE IS THE TECHNOLOGY GAP?

* PROCESSING AND FABRICATION	56.4%
MATERIALS	18.6%
* BOTH	5.6%
NEITHER	19.4%

* 62% IN MATERIALS PROCESSING

REFERENCE: METALS PROGRESS, "SURVEY REPORT", OCT. 1970

TABLE 4

A. D. LITTLE REPORT

LEVELS OF FORMAL EDUCATION OF MANUFACTURING ENGINEERS

High School or Less	20%
College Degree	33%
Some College	47%

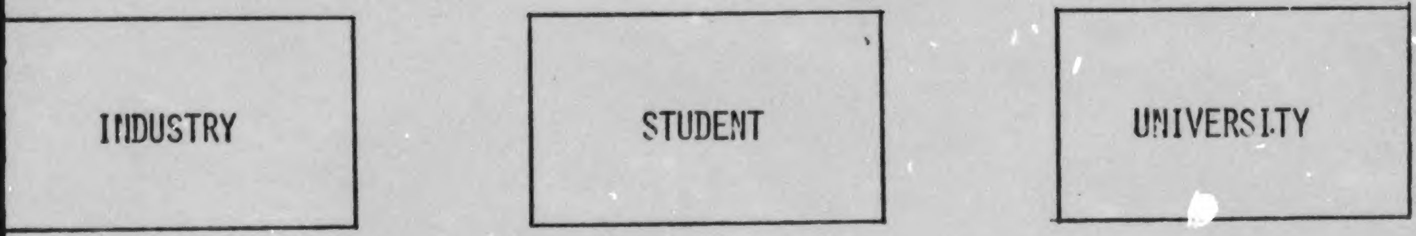

FIGURE 1

think of the university as an "ivory tower" with no connection with the real world. The industrial person may be unaware of technical expertise at the university in his problem area. The university professor may not like the idea of getting his "hands dirty" in the real world of industry. He is unaware of the problems of industry. Consequently, there is a technology transfer problem. However, the student is the secret to the solution of this problem. The student is the main product of the university. The student goes to work for the industry. Therefore, a mechanism of technology transfer involving the student will offer the most potential.

(In this connection, it is noted that Michigan Tech ranks first in the number of Metallurgical engineers graduated each year and ranks third or fourth in the number of Mechanical engineers graduated in the U. S.)

Next consider the characteristics of each of the three identities, as indicated in Figure 2, that can be involved in technology transfer. Industry has an engineering problem or research problem that needs to be solved before a new product can be made ready for production. The industry may lack the expertise that can be potentially applied to these problems. The student sits in between and he is concerned about obtaining an education, expecially one that is relevant and that will help him obtain employment upon graduation.

Figure 3 shows how these three identities with their individual characteristics and concerns can interact via a three man team to enhance technology transfer. The industrial person may be an engineer or other representative from industry. There

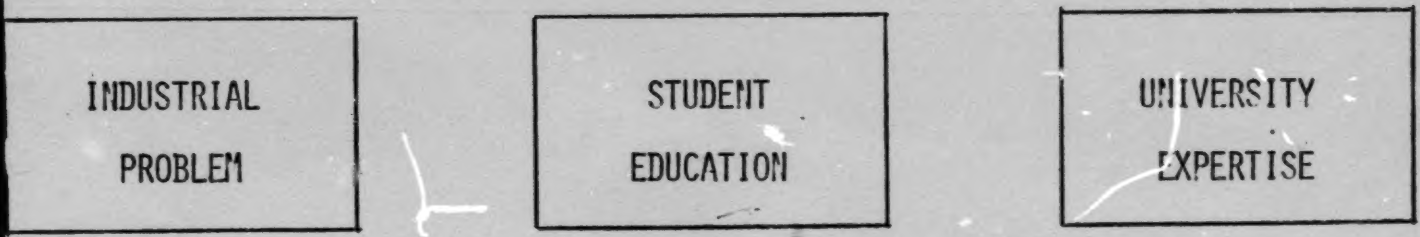
INDUSTRIAL PROBLEM
STUDENT EDUCATION
UNIVERSITY EXPERTISE

FIGURE 2

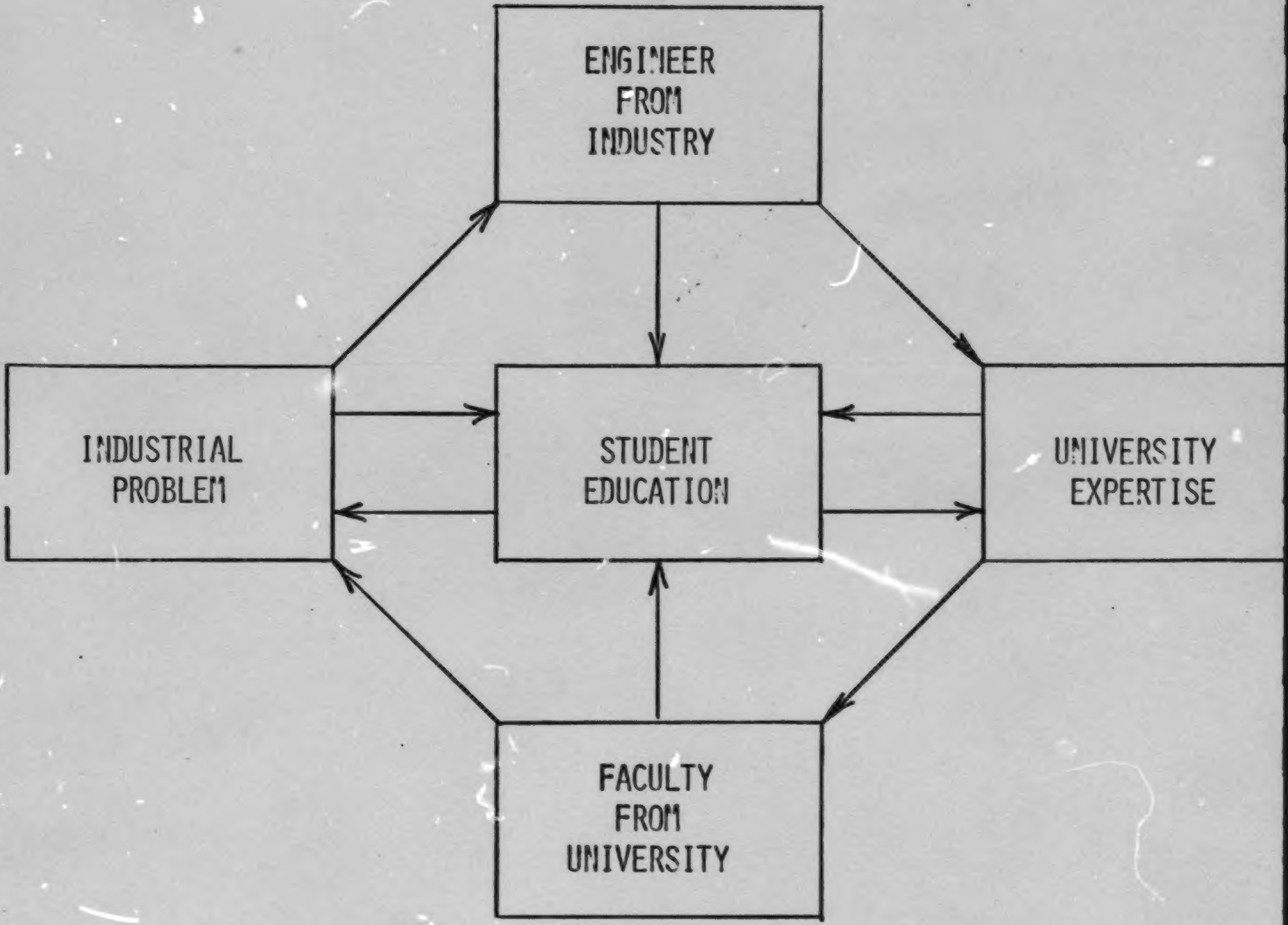

FIGURE 3
INTERACTION OF INDUSTRY AND UNIVERSITY VIA
A THREE-MAN TEAM

may be one or more students involved on this team. The university representative would be a faculty member with particular expertise in the problem area. Figure 3 shows how the university faculty member must get out from the university to interact with industry. It also shows how the engineer from industry must get out from the industry to interact with the university in continuing education or by presenting seminars on campus. The figure also shows how both the industrial and faculty advisors have input into the students' education and how technology transfer can be enhanced if the student moves back and forth between industry and the university. There must be feedback to the university via all three members of the team if transfer of technology to other students and faculty not involved in the particular effort is to be maximized.

Figure 4 shows that the focal point is an engineering project of concern to the industry. This must be the focal point if this mechanism is to work. The need and desire to solve an industrial problem is the "lubricant" that will keep the "bearings from freezing". Without it, "technology transfer" is a good thing to talk about - like the weather, but naturally nothing much will be done about it. The focal point must be an industrial problem about which the mechanism revolves and if it involves a team effort as suggested then technology transfer will automatically be a matter of course.

An internship program, in a medical setting, involves a "hospital" or "clinic". The engineering internship program does too, as shown in Figure 5. In this case the university research laboratories and facilities can serve this purpose when after a

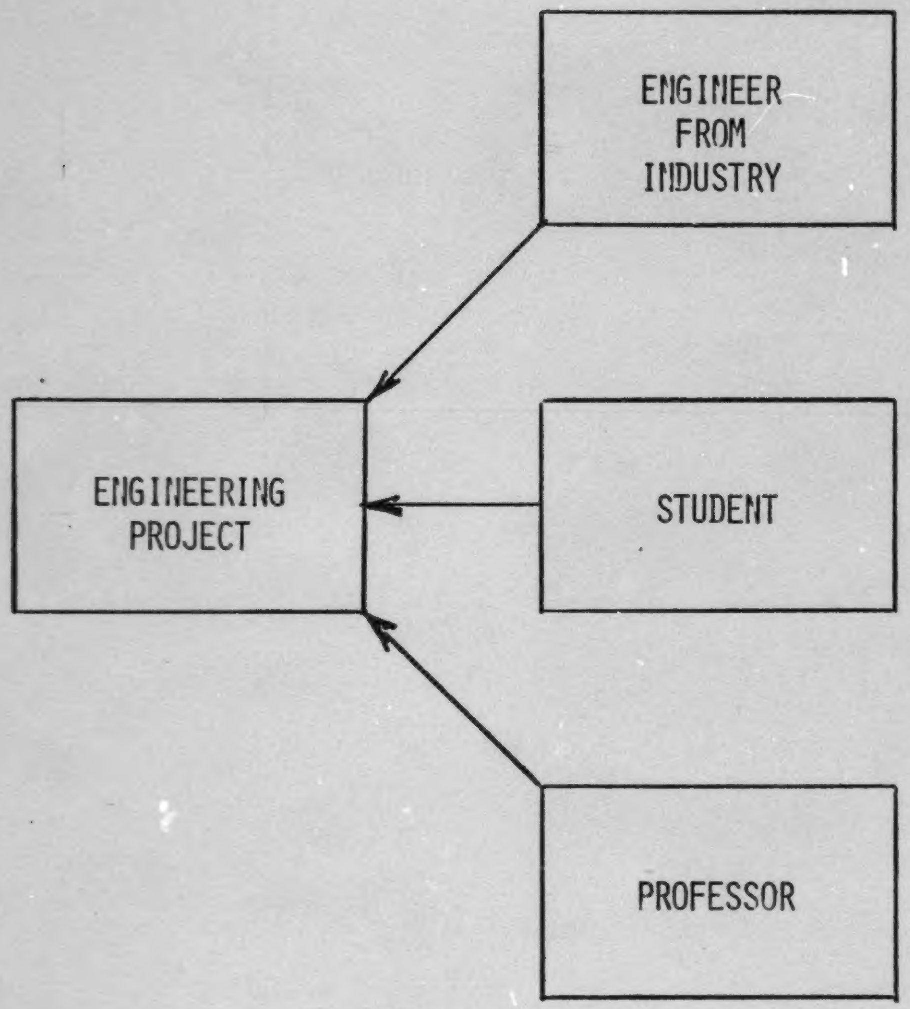

FIGURE 4
FOCAL POINT - AN ENGINEERING PROJECT TO SOLVE THE INDUSTRIAL PROBLEM

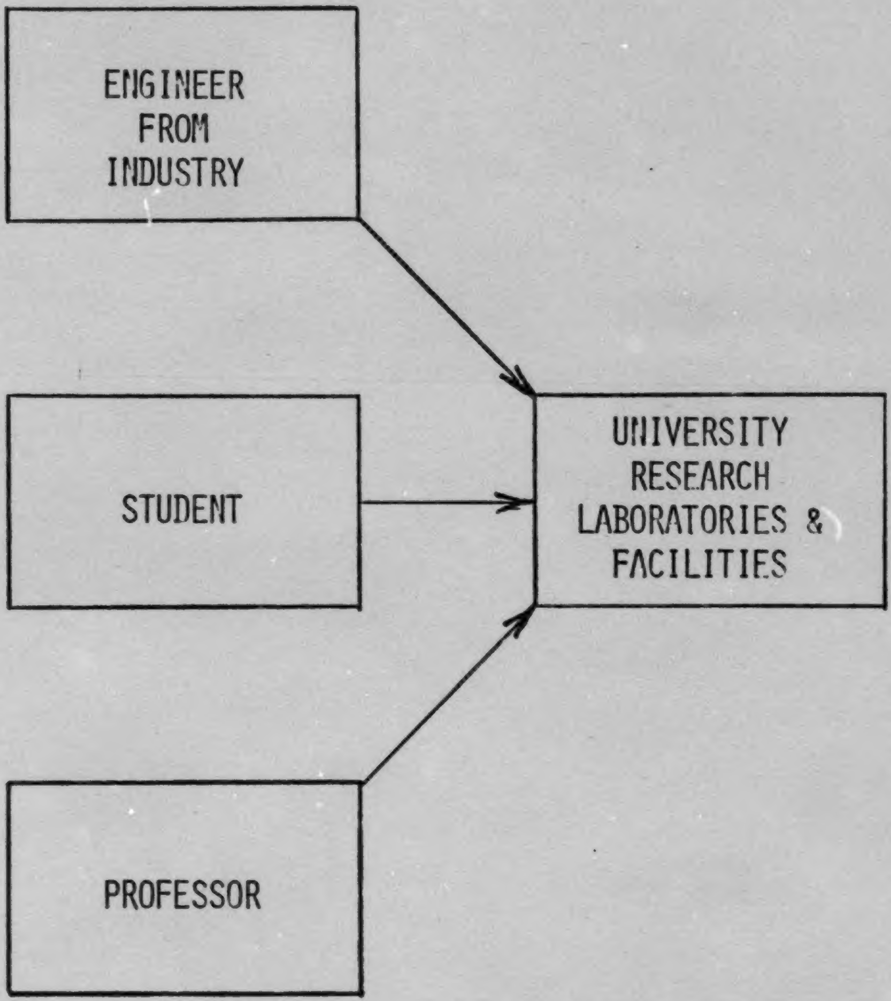

FIGURE 5
THE "HOSPITAL" OR "CLINIC"

particular problem has been diagnosed in industry, it can be further "operated on" at the university.

Figure 6 shows a work study plan (similar to a co-op arrangement) where it is suggested that a student alternately spend 6 months in industry and 6 months at the university. This means that a student's study program would be extended by one year. The program is intended for students entering their senior year and for graduate students. University credit would be given for the engineering research work of the students.

In order to implement the program financial support is needed as shown in Figure 7. To attract the better students to the program, and to convince them to delay their degree schedule by one year, an extraordinary incentive is needed. NSF would support the student while in school with a substantial fellowship. Industry would support the students while at work there, and also would support the faculty working there too - for they need an incentive too. The university, of course, supports the faculty in their teaching duties and provides facilities for education and research.

Michigan Tech proposes the engineering internship program as an experiment for 5 years. This period is considered a minimum in order to collect enough data for evaluation purposes. In this regard, criteria will have to be established for measuring the success of the experiment.

It is believed that this program has the potential of adding "professionalism" to the engineering education, by providing the opportunity of a professional engineering education within an existing engineering school without building a separate professional

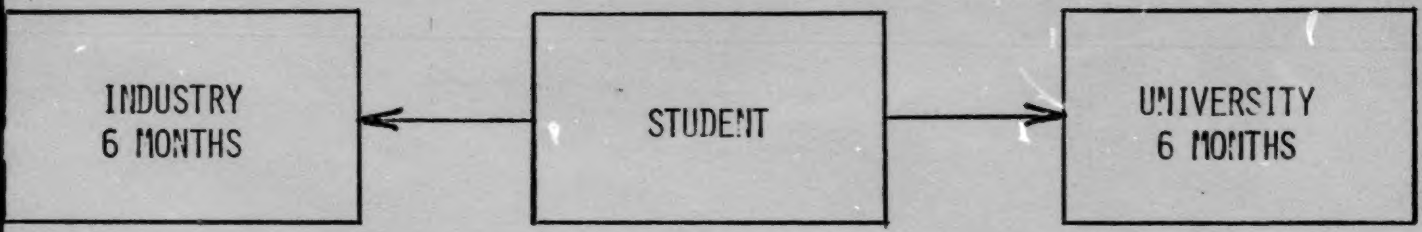

FIGURE 6
WORK STUDY PLAN

FIGURE 7
SUPPORT

NSF - EDUCATIONAL SUPPORT FOR STUDENTS WHILE IN SCHOOL - FELLOWSHIPS

INDUSTRY - SUPPORT OF STUDENTS WHILE IN INDUSTRY
- SUPPORT OF FACULTY WHILE IN INDUSTRY

UNIVERSITY - SUPPORT OF FACULTY AND FACILITIES TO EDUCATE STUDENTS school. The students selected for involvement in the program will truly be the professionals, but the "feedback" and "spin-off" to other students and faculty should enhance the professional character of the engineering education in general.

3. REPORTS ON VISITS ABROAD

REPORTS ON TRIP TO GERMANY

by

K. J. Weinmann
J. C. Gerdeen

Introduction

Two reports on the trip to Germany taken by the authors as part of the NSF background study of university-industry interaction are presented. The first, an introductory report, describes briefly the institutions visited, contacts established, and the types of activity observed. The second report attempts to provide an in-depth description of engineering education and research at the university with emphasis on the area of manufacturing. This report puts the observations of the introductory report in perspective, and clarifies the practices described, and organizations mentioned in it.

INTRODUCTORY REPORT

A. Visit to the Technical University of Berlin - October 16, 1973

1. Persons contacted:

   Prof. Dr.-Ing. Günter Spur, Director of Institut für Werkzeugmaschinen und Fertigungstechnik (Department of Machine Tools and Manufacturing).

   Prof. Dr.-Ing. Rolf Clausen, Assistant Director.

2. Summary of visit:

In addition to the two professors in the department, there are 40 "wissenschaftliche Mitarbeiter" and "Assistenten" (scientific co-workers and assistants) who are doctoral candidates who have their Dipl. Ing. degree.

The research areas of the Institut are four in number:

I. Machine Tools and Metal Cutting
II. Programming of Machine Tools
III. Control Theory
IV. CAD - Computer Aided Design

Some of the projects under these areas are, for example:

Ia. Thermal deformation of machine tools (chucks)
Ib. Thermal aspects of clutches
Ic. Dynamic behavior of grinders (threading)
II. Development of Computer languages: AUTODEC, EXAPT, COMPAC (automatic drawings)
III. Developments of controls: NC, DNC, CNC, AC (Adaptive Control)

The university is leading industry in computer controls and in fact is developing control techniques for industry. Two large industrial firms they work with are Siemens and AEG. These companies furnish the Institut with their computers. There are about 40 sponsored research projects. Of these, 1/3 are sponsored by the government, 1/3 by industry, and 1/3 are co-sponsored by matching funds from government and industrial groups.

B. Visit to Technical University of Stuttgart - October 18,19, 1973

1. Important people contacted:

Prof. Dr.-Ing. Kurt Lange, Director of Lehrstuhl und Institut für Umformtechnik (Institute for Metal Forming); Dipl.-Ing. P. Noack, Assistant Director for Teaching; Dipl.-Ing. G. Schröder, Assistant Director for Basic Research; Dipl-Ing. E. Dannenmann, Assistant Director for Applied Research.

Prof. Dipl.-Ing. Karl Tuffentsammer, Director; and Chief Engineer Dr.-Ing. C. M. Lang, Institut für Werkzeugmaschinen (Department of Machine Tools).

Prof. Dr.-Ing. Hans-Jürgen Warnecke, Director; and Dipl.-Ing. H. Lang, Institut fur Industrielle Fertigung und Fabrikbetrieb (Industrial Engineering).

Prof. Dr.-Ing. H. Stabe, Dean of Fachbereiche für Maschinenbau (Department or College of Mechanical Engineering - includes above 3 institutes).

Dr.-Ing. Jörg Eisenger, Institut für Steuerungstechnik der Werkzeugmaschinen und Fertigungseinrichtungen (Department of Machine Tool Controls and Manufacturing Control).

2. Summary of visit:

Lange's institute has 22 doctoral candidates, four machinists, two research technicians, a librarian, an instrument technician, two secretaries, one draftsman, janitor, electrical technician, metallographer and a photographer.

There is a Council for Cold Forming involving universities and industries - but heavy with industrial representation. There is also a council for sheet metal forming. This body established a laboratory for sheet metal working at the Institute for Metal Forming.

State Support is used to operate the school. 60-70% of research support comes from the government through DFG, 3-5% from industry, 5-7% from an Association of Machine Tool Manufacturers, and 15-20% from AIF - an industrial group with matching funds from government.

Research activities at the Institute for Metal Forming include projects in extrusion, upsetting, heading, coining, flow turning, deep drawing, stretch drawing, bending, cutting, cropping. Work materials include zinc, stainless steel, titanium, and superplastic alloys.

C. Visit to The Technical University of Hannover, October 22,23, 1973

1. Important people contacted:

Dipl.-Ing. Nagel, Dr.-Ing. Liebig - Chief Engineer, Lehrstuhl und Institut für Umformtechnik und Umformmaschinen. (Prof.

Dr. H. Bühler is retired.) Dr.-Ing. Meyer-Nolkemper, Head of FGS - Forschungstelle Gesenkschmieden (Drop Forging Research Institute).

Prof. Dr.-Ing. Hans Kurt Tönshoff, Lehrstuhl und Institut für Fertigungstechnik und Spanende Werkzeugmaschinen.

Meyer-Nolkemper is actually employed by the Drop-Forging Association - but his research group has also been administrated by Prof. Bühler.

Prof. Dr.-Ing. H. Kettner, Lehrstuhl für Arbeitmaschinen und Fabrikanlagen (Industrial Engineering and Production).

2. Summary of visit:

The Drop Forging Research Institute, FGS, which is associated with the Institute for Forming and Forming Equipment, is funded 50% by the Drop Forgers Association and 50% from DFG and AIF.

Research areas in Metal Forming are: Material properties (flow stress of metallic materials); cold forming - sheet metal (bending, rolling, high energy rate forming) drawing of wire, rod, and pipe; hot forming - forging, extrusion, HERF; heat treatment methods; behavior of machine tools of forming.

There is also a Federal Material Testing Lab (Amtliche Materialprüfanstalt für Werkzeuge, Werkzeugmaschinen, und

Umformtechnik) in Hannover closely connected with the University. Three institutes have been appointed to conduct the lab for the government. Dr. Liebig is director. The lab is concerned with grinding wheel safety. There are various safety assurance labs throughout Germany.

There are 17-18 co-workers in Tönshoff's institute, and 12 support staff. Six co-workers are funded by the state - the others by outside support. Support by individual industries is 15%. Support by associations is more than 15%.

Some projects of interest in Professor Tönshoff's institute are: Computer study of wear profile of grinding wheels, residual stresses after machining by electrochemical removal, wear of wire saws for cutting rock, a constant strain-rate cam driven testing machine, surface finish studies in turning of austenitic stainless steels.

D. Visit to Technical University of Aachen, October 25,26, 1973

1. Important people contacted:

   Dr.-Ing. Hans Grabowski, Chief Engineer - Laboratorium für Werkzeugmaschinen und Betriebslehre. Prof. Dr.-Ing. Walter Eversheim, Lehstuhl für Produktionssystematik.

2. Summary of visit:

   Dr. Opitz' institute is now headed by three chairs with three young professors - recent graduates of Aachen.

The other two chairs of the institute besides Eversheim's are occupied by Professor Dr.-Ing. W. König - Lehstuhl für Technologie der Fertigungsverfahren (who also functions as administrative director), and Prof. Dr.-Ing. M. Weck - Lehstuhl für Werkzeugmaschinen.

The lab has 350 staff with 100 co-workers - 40 of these are doctoral candidates.

Research activites under the chair of Manufacturing Processes: Machinability of conventional and exotic materials, and tool life studies using a systems approach (turning, milling, drilling, grinding); Grinding (especially high-speed grinding); Non-conventional machining (EDM, ECM); Development of adaptive control systems (ACC, ACO); Types of activity similar to those observed in Berlin.

E. Visit to DEMAG A.G., Duisburg, October 30, 1973

1. Person contacted:

   Dipl.-Ing. Scherf, Director of Technical Services

2. Summary of visit:

   Mr. Scherf reinforced the impressions we got while visiting the universities. He confirmed that excellent relations exist between universities and industry. He is satisfied to let the universities take a leading role in the type of research and development, which in the U.S. is generally conducted by industry itself. He likes the idea of R&D being sponsored and/or carried out by a consortium of industrial firms, who share the results. Philosophy in Germany appears to be that proprietary aspects must take a back seat to cooperation. With regard to the engineers currently turned out by the technical universities, he has nothing but the highest praise for them and their qualifications. Mr. Scherf would like to be kept informed of our continuing efforts.

F. Visit to the BMFT - Federal Ministry of Research and Technology - Bonn, October 31, 1973

1. Person contacted:

   Dr. rer. nat. B. M. Kramer

2. Summary of visit:

   Research and Technology holds the purse strings, establishes research needs, and dispenses funds accordingly. Moneys go to DFG, industry (on a matching fund basis), the Max Planck Institute (basic research), Fraunhofer Society (applied research), federal research institutes, etc. It appears the universities may be funded directly also, but generally federal moneys reach them indirectly through DFG and industry, for instance. In the case of the important areas of NC of machine tools and CAD/CAM, for instance, the funds go first to the Society for Nuclear Research, which is termed the Project Carrier. It hands funds down to the specific area of machine tools which is headed by a Project Associate, in this case, Prof. emeritus Dr.-Ing. H. Opitz, who coordinates this research effort. Additional research funding comes from AIF, VdW (Machine Tool Builders Ass'n.) and the Volkswagen Foundation. All funding agencies inform each other of their activities on a voluntary basis to avoid duplication of efforts. Hence, coordination of research efforts is not only carried out horizontally (i.e. agreement among universities) but also vertically, by all public and private agencies.

Dr. Kramer mentioned that patent and use rights of the Government itself are not yet well defined and under continued study.

G. Visit to DFVLR - German Research and Testing Institute for Aero-and Astronautics - Location Porz-Wahn, October 31, 1973

1. Person contacted:

   Dr.-Ing. H. Barth (Gas turbine research)

2. Summary of visit:

   This federal research effort is carried out in different locations in Germany, with several institutes on each location. Cooperation is again evident. Involved are not only universities, but international agencies from within Western Europe all the way to NASA. We saw full size models of several research and communication satellites which were the culmination of international efforts. Customarily, such satellites are heaved into space by U.S. rockets.

A STUDY OF UNIVERSITY-INDUSTRY INTERACTION IN GERMANY

by

K. J. Weinmann
and
J. C. Gerdeen

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GLOSSARY OF TERMS

AIF - Arbeitsgemeinschaft Industrieller Forschungsvereinigungen - Cooperative of Industrial Research Associations

BMFT - Bundesministerium für Forschung und Technologie - Federal Ministry for Research and Technology

DFG - Deutsche Forschungsgemeinschaft - German Research Association, similar to NSF

DFVLR - Deutsche Forschungs-und Versuchsanstalt für Luft-und Raumfahrt - German equivalent to NASA

FhG - Fraunhofer Gesellschaft - Applications oriented research society

HGF - Hochschulgruppe Fertigungstechnik - University Committee for Manufacturing Engineering

MPG - Max Planck Gesellschaft - Research society for basic research

VDW - Verein Deutscher Werkzeugmaschinenfabriken - German Machine Tool Builders Association

A. A Brief Description of the Organizational Setup of a German Technical University

1. General Structure

The German technical university functions differently from an American university in several respects. (See Fig. 1) [1]. The university has neither colleges nor departments in the Anglo-American tradition. Instead, the basic functional and administrative unit is the *Institut*. The *Institut* is more restricted in scope than a department, and yet its director generally wields more power than the U.S. department head, as will be explained below. The *Institut* can best be visualized by imagining an American engineering department, say a department of mechanical engineering, being dissolved into its basic components, such as machine design, thermodynamics, metal removal, etc., and converting each into an institute with its own administrative apparatus. Mechanical Engineering would no longer be an administrative unit, but would merely remain a descriptive concept. At the University of Stuttgart, for example, mechanical engineering is one of 15 academic directions (*Studienrichtungen*), some others being civil engineering, electrical engineering, etc. Naturally, the institutes tend to be quite small, and there are over one hundred of them at the University of Stuttgart alone. Several institutes are bundled into divisions (*Fachbereiche*), such as energetics, manufacturing engineering, process engineering; and there are 18 *Fachbereiche* in M.E. If the division of manufacturing engineering is singled out, one finds that it is made up of eleven institutes, some of which do not appear to have a direct bearing on manufacturing.

ACADEMIC STRUCTURE OF THE UNIVERSITY OF STUTTGART
WITH EMPHASIS ON MANUFACTURING ENGINEERING

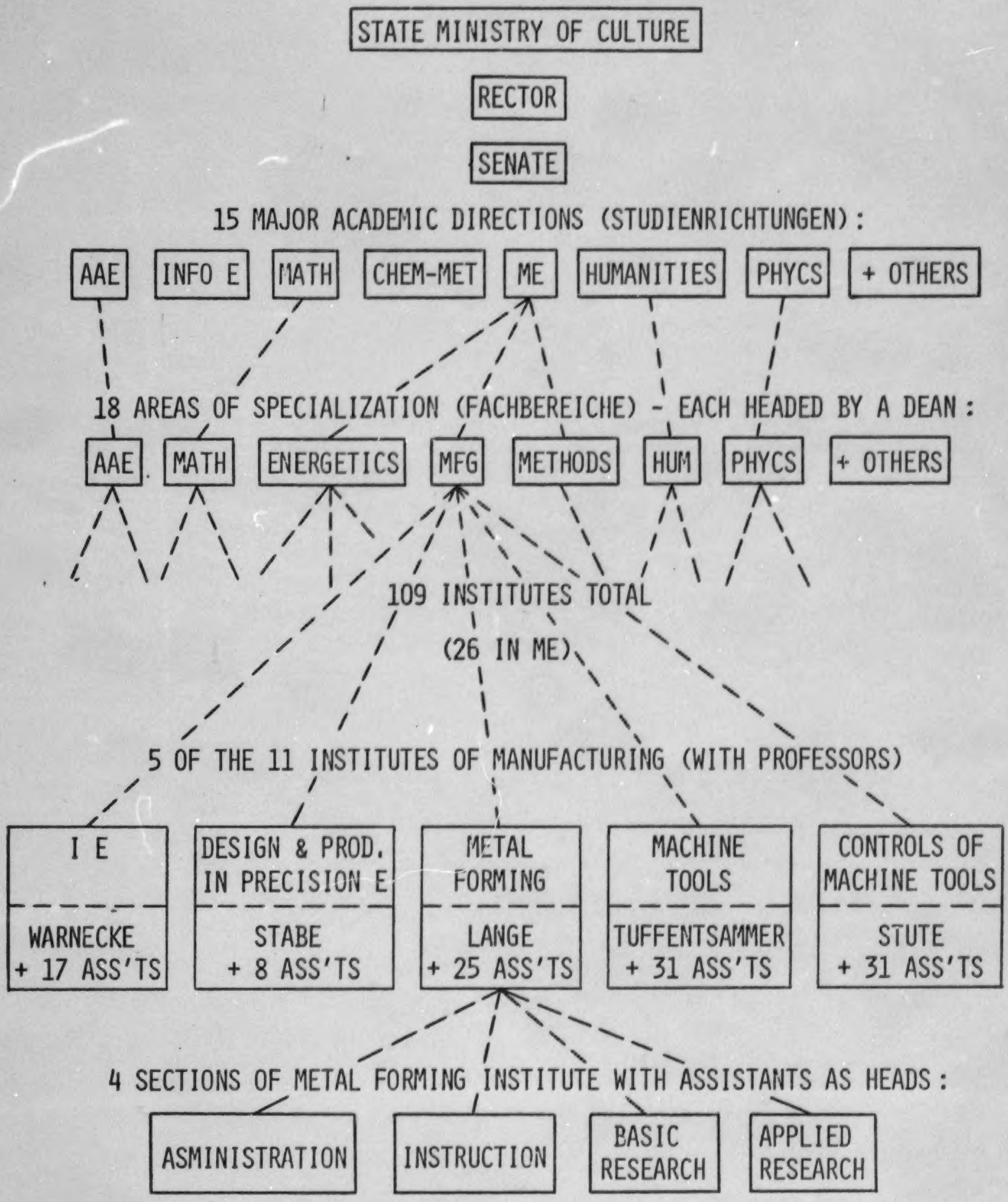
STATE MINISTRY OF CULTURE
RECTOR
SENATE
15 MAJOR ACADEMIC DIRECTIONS (STUDIENRICHTUNGEN):
AAE
INFO E
MATH
CHEM-MET
ME
HUMANITIES
PHYCS
+ OTHERS
18 AREAS OF SPECIALIZATION (FACHBEREICHE) - EACH HEADED BY A DEAN:
AAE
MATH
ENERGETICS
MFG
METHODS
HUM
PHYCS
+ OTHERS
109 INSTITUTES TOTAL
(26 IN ME)
5 OF THE 11 INSTITUTES OF MANUFACTURING (WITH PROFESSORS)
I E
WARNECKE + 17 ASS'TS
DESIGN & PROD. IN PRECISION E
STABE + 8 ASS'TS
METAL FORMING
LANGE + 25 ASS'TS
MACHINE TOOLS
TUFFENTSAMMER + 31 ASS'TS
CONTROLS OF MACHINE TOOLS
STUTE + 31 ASS'TS
4 SECTIONS OF METAL FORMING INSTITUTE WITH ASSISTANTS AS HEADS:
ASMINISTRATION
INSTRUCTION
BASIC RESEARCH
APPLIED RESEARCH

FIG. 1

Those having to do directly with manufacturing are indicated in Fig. 1. The *Fachbereich* is presided over by the dean, who is elected from amongst the institute directors of the particular division for a two-year term. As *primus inter pares*, he has very little power. Customarily the director is the sole professor at the institute, and is able to develop his institute according to his own taste, interests, capability, as well as the opportunities provided by the prevailing economic needs. It is thus possible that some institutes may grow to be quite large, and rival American engineering departments in size.

2. Organization of the Institute

The professor (institute director) relies on his staff of *wissenschaftliche Mitarbeiter* and *Assistenten* (scientific co-workers and assistants) to shoulder many of the responsibilities in the administration of the institute and to carry out and supervise research. They act as heads of sections such as instruction, applied research, basic research, and administration as is the case at the *Institut für Unformtechnik* (Institute for Metal Forming) of the University of Stuttgart (Fig. 1), for example. Different institutes have different sections according to their missions. The assistants, in turn, may have assistants of their own, who are usually students pursuing the *Diplom Ingenieur* (approximately equivalent to the M.S.). In addition, there is an impressive support staff, which includes secretaries, machine shop technicians (usually 3 to 5), draftsmen and designers, and if need be, metallographers, and photo lab personnel.

3. Qualifications of Institute Staff

The director of the institute, who enjoys the academic title *Ordinarius* (o. Prof.), is called by the university to fill the vacant chair of the institute. More precisely, the university makes a recommendation, and the call is issued by the ministry of culture of the state which supports the university. This act in part explains the power of the *Ordinarius* within the university: He is hired and paid by the state, and not the university. In engineering, the call will usually go to a professor of another university, or a highly successful engineer in industry. For an engineering professorship, several years of industrial experience gained in a leading industrial position are a requirement. It is customary to pick a man with a doctorate, although this does not appear to be a requirement. He is a recognized leader in his field, one of the foremost experts in the area of emphasis of the institute. Before an interested candidate accepts the job, he enters into negotiations with the state, in order to lay down his conditions. He will negotiate for money to build up the institute, library funds, etc. If his conditions are met, he takes the job. It happens, on occasion, that the negotiating parties cannot get together, in which case a different candidate must be found. The professor is a civil servant, and thus has the ultimate in job security.

The *wissenschaftliche Mitarbeiter* and *Assistenten* generally have their *Diplom-Ingenieur* and are candidates for the Dr.-Ing., the equivalent to the Ph.D. There are assistants, however, who have completed their doctorates. Although assistantships can be compared to assistant professorships, they are not permanent. It should be emphasized that most German doctoral candidates in engineering, unlike their U.S. counterparts, are not considered to be students. They have no course requirements, and the attainment of the degree is solely dependent upon the dissertation. Some assistants become so involved with institute work, that they never complete a dissertation. In this case, the years spent at the institute are not considered to be lost, on the contrary: the assistant has had the chance to build his visibility with industry, and his administrative and engineering activities have made him highly desirable to industry. Besides, throughout his tenure as assistant, he is paid according to the industrial pay scale, i.e. about $1,000 per month.

4. Financing of the Institute

The institute receives its operational budget directly from the state. This supports the director, a few of his assistants, the support staff, office supplies, etc. Additional assistants are funded from research. Research support comes from government as well as industry, as explained below. Machinery in the laboratories is given or loaned by industry. In fact, machine tool manufacturers are eager to place their hardware into university labs for advertising purposes. Industry is also occasionally asked to donate materials and supplies not budgeted.

5. Teaching at the Institute

In general, lectures are the responsibility of the *Ordinarius*. This certainly applies to required courses and consequently to courses contained in the options. (See Part B for explanation of options.) Assistants are involved in preparation and updating of lectures, however, and lab instruction and supervision is their responsibility. It is standard practice to invite guest lecturers from industry, who will discourse on their areas of specialization. They may teach for an entire semester, or come for a day only. There exist different types of these professors and lecturers, and it is beyond the scope of this report to devote time to the description of the differences. Suffice it to say that none of them have the status of the *Ordinarius*.

It should be emphasized at this point that engineering education is very much applications-oriented and generally geared so that the graduate from the *Institut* can be productive immediately upon entering industry. This is of course due to the industrial exposure which the professor brings with him to the university. He also brings with him good contacts in industry, and companies provide the institute with research contracts (see below). Since this type of research will necessarily be of the applied type, and since research affects instruction, engineering education has assumed its applied flavor. Industry has a high degree of appreciation for the engineers turned out by the universities, and has come to expect from the universities that they continue to produce engineers of this quality.

Cooperation among institutes appears to be widely practiced and there is little evidence of a "go it alone" attitude. If feasible, and whenever practical, they share facilities, and they draw upon each others' expertise to provide their students with a well-rounded engineering education. The curriculum for metal forming, for instance, which will be described in a later section, places considerable emphasis on materials science in recognition of the fact that material properties as well as mechanical aspects play a major role in the processing of metals. Material science, however, is offered in the Institute for Metallurgy.

If the need arises, institute staff members are recruited from different areas. As an example, control of machine tools involves considerable electrical engineering know-how. It is thus significant that generally about half of the assistants working in this area are electrical engineers. In fact, the director of the Institute for Control of Machine Tools at the University of Stuttgart (Fig. 1), is an electrical engineer himself.

By and large, good and fruitful relations are cultivated between the professor and the former student now in industry. This of course is instrumental in maintaining the intensive university/industry interaction generally found in Germany, which is enlarged upon in the section dealing with research.

B. Education of an ME Student Specializing in Manufacturing Engineering at a German University

1. Qualifications of Students

Graduation from high school (*Abitur*), which ends 13 years of primary and secondary schooling, qualifies the student for a university education. He brings with him a substantial exposure to liberal arts (world history, art and music appreciation, philosophy, rhetoric) including the knowledge of at least one foreign language. Generally, he has a working knowledge of English and/or French.

The engineering student is therefore not required to take any coursework of this type, but will start out with science courses immediately instead. He generally has had math through calculus, physics, and chemistry. The fact that he has had one additional year of pre-university schooling than his U.S. counterpart in conjunction with a more demanding high school education usually puts the German high school graduate at the beginning Junior level of a U.S. university. For a more detailed description of high school education in Germany, see [2].

2. Practical Experience *(Praktikum)*

Before he can obtain his degree, the engineering student is required to spend at least 26 weeks in industry in order to gain some practical experience in his area. Evidence of 8 weeks must be presented by the student at his matriculation [3].

The purpose of the experience is for the M.E. student to acquire knowledge of the origin and refinement of workmaterials as well as their fabrication, and to gain an understanding of the product, i.e. its structure, and how it functions. The student is not expected to develop skills. The student is also to become familiar with organizational aspects of industry as well as the attitudes and behavioral patterns of workers.

The experience the student gains should be structured as follows:

1. Manual working of materials
2. Work with machine tools - metal cutting and forming
3. Model building, foundry

4. Heat treating, welding
5. Measuring, testing, quality control
6. Assembly and repair

The responsibility for training the student lies with the companies alone. The universities provide the guidelines only, and exercise no control. It is recommended that the student work at more than one company.

The remuneration of the student generally is marginal to non-existent in the initial phase of the program. After he has attended school for a number of semesters, and can be productive, his pay is increased.

The student is required to report on his activities, observations and experiences in writing. He is expected to present proof of his training activities to the university, and the company issues him a report card for this purpose.

The Zurich Model [4] - The conventional *Praktikum* described above has come under attack by the universities since a lack of control by the educators over the program has resulted in non-uniform training among students. Some companies take the *Praktikum* more seriously than others, but some individual supervisors may fail to do a good job.

In answer to this situation, German technical universities are taking a closer look at the "Zurich Model", a more efficient version of the conventional *Praktikum* introduced at the *Institut für Werkzeugmaschinenbau und Fertigungstechnik* of the Technical University of Zurich, Switzerland. Special features of this program include briefness - 18 weeks as opposed to 26 for the conventional program - and greater efficiency; although the objectives remain essentially as outlined above. Efficiency is achieved by conducting the *Praktikum* in two parts: 1. There is a structured course of 6 weeks duration with only enough flexibility to allow for varying facilities or capabilities among companies. The course is run by industrial instructors on location in industry, with as many as 8 students per class. The instructor himself is trained by the university. 2. The balance of the *Praktikum* is spent in free, unstructured training of the student.

The reaction to this experiment by the participants is reported to be generally positive, and Swiss industry has taken on the added financial burden with no hesitation.

The *Praktikum* may lead to additional summer employment for those students interested in gaining further experience and supplementing their income. Co-op programs, on the other hand, as they are practiced in the United States, apparently do not exist in Germany.

3. Curriculum

The description of the academic program which follows is based upon the curriculum of the University of Stuttgart [1,5]. It has been found that the other engineering schools in Germany follow the same pattern of engineering education, thus presenting a specific program as example is justified. Academic standards do not vary to any extent among engineering schools, so that transfer between universities involves few complications.

The goal of the entering student is to obtain the degree of *Diplom Ingenieur*, the first of two possible academic degrees.

The second degree is the Doctorate (Dr.-Ing.). The *Diplom Ingenieur* corresponds roughly to the M.S. in the U.S., as indicated earlier.

The academic program falls into two parts (Fig. 2), each of which requires a comprehensive examination. The first part covers four semesters of general course work, common to all ME programs, which provides the student with a theoretical background (Table 1). One major and several minor plant trips are also included. The student must pass the comprehensive examination covering this material to complete this phase. Only then can he get credit for the remaining semesters, and complete his degree work.

From the fifth semester on through the eighth and beyond, the student is pursuing a major (*Studiengang*) of his choice, say manufacturing engineering. Within this category he has to select two options (*Hauptfächer*) consisting of a number of courses each (14 semester hours), and six required courses (*Pflichtfächer*) of four semester hours each. The areas of specialization in M.E. are given in Table 2, and the options and electives in manufacturing in Table 3.

Within each of the two options, the student selects a number of courses. The six required courses, which can be called electives, are above and beyond the courses contained in the options. Specifically, a course is to be selected from each of the six areas listed in Table 3, provided a choice exists.

Comparison with Fig. 1 shows that each of the options represents a different institute, as do the elective areas.

CURRICULUM LAYOUT IN MANUFACTURING ENGINEERING AT UNIVERSITY OF STUTTGART

SEMESTER	1	2	3	4	5	6	7	8	9+
PARTS OF ACADEMIC PROGRAM	BASIC BACKGROUND COURSES COMMON TO ALL M. E. STUDENTS				SELECTION OF TWO OPTIONS FROM: 1. MATERIALS PROCESSING (FORMING) 2. CONTROLS ENGINEERING 3. MACHINE TOOLS 4. INDUSTRIAL ENGINEERING PLUS SIX ELECTIVE COURSES REQUIRED				
EXAMS				INTERMEDIATE COMPREHENSIVES (VORDIPLOM)				FINAL COMPREHENSIVES (DIPLOM)	
PROJECTS					SEMINAR PRESENTATION PLUS MAJOR TECHNICAL PROJECT IN EACH OF THE TWO OPTIONS				DIPLOM THESIS
LABS	MAT'LS TESTING	PHYSICS MAT'LS TESTING	ELECTR. ENGG.		ONE LABORATORY CONSISTING OF TEN EXPERIMENTS IN EACH OF THE TWO OPTIONS				

FIG. 2

CURRICULUM FOR FIRST FOUR SEMESTERS FOR MECHANICAL ENGINEERS

(UNIVERSITY OF STUTTGART)

	SEMESTER HOURS
Introduction into Mechanical Engineering	2
Introduction into Law	2
Economics	2
Introduction into Studies of Engineering Sciences	2
Design of Machine Elements & Strength of Materials	21
Advanced Mathematics	21
Mechanics	17
Thermodynamics	6
Descriptive Geometry	4
Electrical Engineering	8
Metrology	5
Physics	9
General Chemistry	2
Material Science	5
Manufacturing with Plant Visits	4
Semester Contact Hours up to Pre-Diplom	110

CURRICULUM FOR AREA OF SPECIALIZATION

6 Electives	24
Project in One Elective	3
First Option	20
Project for First Option	6
Second Option	20
Project for Second Option	6
Diplom Thesis	6
Total Semester Contact Hours	195

Table 1

8 AREAS OF SPECIALIZATION IN MECHANICAL ENGINEERING

(University of Stuttgart)

Energy Engineering
Engineering Physics
Traffic Engineering
Manufacturing Engineering
Precision Engineering
Machine Design
Methods Engineering
Process Dynamics and Process Control

--For Machine Design, for example, typical courses are:

Strength of Materials
Machine Dynamics
Vibrations
Transmissions
Hydraulics
Industrial Engineering
Theory of Automatic Controls
Heat and Mass Transfer
Data Processing
Machine Tools

Plus two options, in which one or the other of these courses may already be contained

Table 2

OPTIONS IN MANUFACTURING ENGINEERING

(UNIVERSITY OF STUTTGART)

METAL FORMING

AUTOMATIC CONTROLS

MACHINE TOOLS

INDUSTRIAL ENGINEERING

6 ELECTIVES chosen from:

1) & 2) A. Metal Forming
B. Introduction to Controls Engineering
Automatic Control of Machine Tools
C. Machine Tools
D. Industrial Engineering
3) Metrology
4) Science of Metallic Materials
Strength of Materials
5) Computer Lab & Numerical Methods
6) A. Manufacturing Methods of Precision Engineering
B. Machine Dynamics
C. Vibrations
D. Automatic Controls
E. Information Theory

Table 3

The coursework of the second part is specialized, of course, and is intended to provide the student with the opportunity to gain in-depth knowledge of selected topics. This is particularly true of the options. In each of the two options and in one of the six electives, the student is required to carry out a major technical project. In general he is to work independently and is to submit a report describing his endeavors and findings. He thus has three reports in total. As an example, the student could involve himself in a design project for one of these projects. A seminar-type presentation is to be made of one of these projects. Each option also includes a lab course with ten experiments.

Tables 4 and 5 show options in metal forming. One is primarily applications (production) oriented (Table 4), the other stresses basics. A comparison of these options reveals a few interesting features. The production option heavily stresses machine tools and topics related to controls of machine tools and automation. The fundamentals option, on the other hand, is more theoretical in nature, and places substantial emphasis upon materials. It is clear that in each case metal forming is presented in context with a larger picture. The production-oriented engineer is interested in the process itself, and is thus involved with machines. The engineer dealing with basic aspects of forming is concerned more with the behavior of materials, in addition to the processes.

The student has two more efforts left to fulfill the requirements of his degree. These are the final comprehensive examination, and the *Diplomarbeit* (comparable to M.S. thesis). He must have

I. OPTION "METAL FORMING - PRODUCTION" AT THE INSTITUT FÜR UMFORMTECHNIK, UNIVERSITY OF STUTTGART

	SEMESTER HOURS
A. REQUIREMENTS:	
FUNDAMENTALS OF METAL FORMING	6
MACHINE TOOLS OF METAL FORMING	2
SPECIAL TOPICS IN FORMING PROCESSES REGARDING PRODUCTION & DEVELOPMENT	2
B. 4 HOURS TO BE SELECTED FROM	
SPECIAL FORMING METHODS	1
THEORY OF ALLOYING - NONFERROUS METALS	2
CONTROLS OF MACHINE TOOLS	4
MACHINE TOOLS	3
SYSTEMS ENGINEERING	2
AUTOMATION	2
STATISTICAL QUALITY CONTROL	2

C. SECOND OPTION FROM

AUTOMATIC CONTROLS
MACHINE TOOLS
INDUSTRIAL ENGINEERING

D. RECOMMENDED ELECTIVES

1,2. ELECTIVE FROM AREAS NOT SELECTED AS OPTION
3. MATERIAL SCIENCE
4. COMPUTER LAB & NUMERICAL METHODS
5,6. ELECTIVE FROM APPROVED LIST

TABLE 4

II. Option "Metal Forming - Fundamentals" at the Institut für Umformtechnik, University of Stuttgart

A. Requirements:

	Semester Hours
Fundamentals of Metal Forming	6
Analysis of Forming Processes by Theory of Plasticity	1
Machine Tools of Metal Forming	2

B. 5 hours to be selected from

Special Topics in Forming Processes	2
Materials Science	2
Strength of Materials	4
Theory of Wear	2
Theory of Alloying - Nonferrous Metals	2
Theory of Alloying - Nonconventional Metals	2
Systems Engineering	2
Advanced Mechanics	3

C. Second Option from

- Manufacturing Topics
- Materials

D. Recommended Electives

- Computer Lab & Numerical Methods
- Materials Science
- Science of Plastics
- Strength of Materials
- Plus Electives from Approved List

Table 5

passed the examination before he can get credit for the *Diplomarbeit*. The examination covers both options and the elective courses, and the three projects and the thesis are evaluated as part of the exam. His thesis work is carried out in one of the options.

Since the projects and the thesis are quite time consuming, it is unlikely that the student will finish in four years. The more frequently encountered norm is six years.

When the student leaves the university, he is a licensed professional engineer, for his *Diplom* is his professional engineering certificate.

C. Research in Manufacturing Engineering

Research at the university cannot be considered without observing the research picture in Germany as a whole. There exists a high degree of interdependence between university, industry, and federal government regarding research efforts. As we expand into this subject, it might be of interest to start out by indicating briefly the agencies involved in research besides the universities, regardless of the research thrust.

1. Research Organizations

Max Planck Gesellschaft (MPG), [6] - The 52 institutes of the Max Planck Society restrict their efforts to basic research. They specialize in tasks which have to be carried out outside a university, and which are preferably concentrated in one location. Nevertheless, close ties exist between the Society and university research, as evidenced by frequent shifts in personnel in both directions, and cooperative research endeavors. Due to its achievements, it enjoys an excellent worldwide reputation. For example, one of the recipients of the 1973 Nobel Prize in Medicine is a member of the Max Planck Institute of Behavioral Physiology.

Federal and State governments provide about 90% of the budget of the Society, the balance coming from industry and research contracts.

Fraunhofer Gesellschaft (FhG), [6] - This Society serves as agency administering applied research. Thus it can be considered to be the applied counterpart to the MPG, and fills the gap between MPG and industrial research. Its 30 institutes and research groups carry out research contracts from industry and government in addition to their own projects.

Funding is provided by the Federal Government, state governments, and the private sector.

Cooperation with universities is close, and a number of its institutes are attached to university institutes. For example, the FhG Institute for Production Methods and Automation is attached to the Institute of Industrial Engineering, University of Stuttgart.

One of the institutes of the FhG deserving special attention is the Institute for Systems Technology and Innovation Research, ISI, which was founded in 1972 [7]. It concerns itself with 1. technology assessment by dynamic simulation, 2. innovation research analyzing the mechanisms of technological progress, as conducted by MIT, Harvard, Stanford Research Institute, A. D. Little, etc., in the U.S., for example, and 3. technology transfer aimed at developing certain goods and services, as promoted by the Experimental R&D Incentives Program of NSF in the U.S., for example.

Arbeitsgemeinschaft Industrieller Forschungsvereinigungen (AIF)[8] - The consortium of Industrial Research Associations coordinates the research efforts of 35 or so member associations representing industry, whose research interests are strictly of an applied nature. Research contracts are awarded to research institutes like those of the FhG and the universities. Associations particularly important to university institutes conducting research in the areas of metal cutting, machine tools and control of machine tools are the German Machine Tool Builders Association (VDW) and the Research Association for Program Languages of Manufacturing Systems.

Funding is provided by industry, of course, with additional moneys supplied by the Ministry of Economics.

Deutsche Forschungs-und Versuchsanstalt für Luft-und Raumfahrt (DFVLR), [9] - The Federal Government sponsors a number of major high-expenditure research projects, which are generally carried out by the MPG, universities and industry. These include the nuclear research program, data processing program, and the aerospace program. The latter is of interest, since it is the only program with its own research organization, the DFVLR, the German equivalent to NASA. This organization consists of 40 research institutes which are funded by Federal Government, state governments, and third parties. The DFVLR concentrates on technological R&D, while the MPG and universities conduct basic aerospace research. The cooperation between all of these groups is, of course, quite close.

2. Agencies Providing Research Funding

Bundesministerium für Forschung und Technologie (BMFT) - Basically, research is funded by Federal and state governments, industry, or both. The most prominent source is the Federal Ministry of Research and Technology. Although a number of Federal ministries is involved in providing research funding, such as the ministries for finance, economics, defense, and transportation, the overwhelming amount of research money is appropriated by the BMFT. Formerly all matters regarding research and technology were administered by the Federal Ministry of Education and Science. Recently, the BMFT spun off from Education and Science, and established itself as an independent ministry, so that Education and Science as well as Research and Technology are now both represented at the cabinet level, each by its own secretary. The BMFT establishes research priorities and needs, and dispenses funds accordingly. Recipients are research agencies whose projects are funded directly due to their substantial financial involvement or mission, such as MPG, FhG, DFVLR, and universities.

Deutsche Forschungsgemeinschaft (DFG), [10] - The most important agency supporting the research effort at universities is the German Research Association, the German counterpart to the NSF. This 50 year old organization supports research in all disciplines, especially basic research, basic research oriented towards application, but also applied research. It apparently is not involved with major research efforts which are carried by the BMFT directly. DFG moneys are supplied by the Federal and state governments in about equal proportions, as well as industrial foundations and others. In 1971, about 95% of the DFG D-Marks came from the governments. The budget has increased from about 100 Million DM in 1962 to about 380 Million DM in 1971, and needs of 876 Million DM have been projected for 1974.

Moneys are appropriated in three general categories:

a) for individual research projects based on their merit without consideration of current research trends and priorities (*Normalverfahren*);

b) for projects whose objectives are in tune with research programs encouraged by DFG (*Schwerpunktverfahren*);

c) for special research areas (*Sonderforschungsbereiche*), the qualifications for which consist of research capabilities of an interdisciplinary character established by coordination and consolidation of scientific manpower and university facilities, enabling work on special projects of considerable magnitude and cost.

Industrial Foundations - In relatively recent years, industrial foundations have begun to shoulder some of the burden of financing research [6]. The foundation mentioned most frequently in connection with research in the area of Manufacturing is the Volkswagen Foundation (*Stiftung Vokswagenwerk*). Although the involvement of the foundations is modest as compared to that of the governments, their participation in the research efforts of Germany has been widely welcomed by research institutions.

3. Research at the Manufacturing *Institut*

Currently, manufacturing-oriented institutes exist at ten German universities. Within the field of manufacturing engineering, strong emphasis is placed upon metal cutting, machine tools, and machine tool controls. All four universities visited were heavily engaged in these activities. This fact has historic roots in the establishment of a chair for machine tools and industrial engineering at the forerunner of the TU Berlin shortly after the turn of this century, as the first chair of its kind [11]. This precedent helped to launch manufacturing engineering as one of the most important mechanical engineering activities in Germany. The research effort in the area of manufacturing can best be illustrated by the number of assistants at the institutes, since the assistants generally are involved in research. One frequently finds upward of 20 assistants in these institutes (See Fig. 1), with as many as 100 at the *Laboratorium für Werkzeugmaschinen und Betriebslehre*, Technical University of Aachen. To manufacturing engineering circles in Germany, this emphasis is natural in light of the fact that 10 percent of industry is directly involved in machine tool building, and 90 percent of the remaining industries are involved in manufacturing in one form or another.

Since 1937, the majority of the manufacturing institute directors belongs to the *Hochschulgruppe Fertigungstechnik* (HGF), the University Committee for Manufacturing Engineering. The aim of the HGF is to coordinate research in the area of manufacturing engineering and machine tools among the universities to promote scientific work by mutual information, and to cooperate with Federal and state institutions and industry in the planning and execution of research projects. Further coordination of research efforts across national boundaries is attempted by C.I.R.P. Thus, by dividing up the research effort among the universities, competition for funding is substantially reduced and duplication in research minimized. Nevertheless, overlap in the heavily emphasized field of CAD-CAM (computer aided design and computer aided manufacturing) is present, as each of a number of schools work on different systems to accomplish similar goals.

Interestingly enough, there is no recognized quality gradient among universities, as they appear to consider each other as equals. This attitude facilitates the kind of cooperation just described. The close coupling of university and industry in research incorporates certain features which are worth pointing out. First of all, there appear to be few, if any, industrial manufacturing research labs in Germany, since industry relies on universities for much of its research needs. This has provided universities with technology leads over industry in certain areas, especially in CAD/CAM. The universities appreciate their position, and are anxious to maintain it by continued good cooperation with industry. The funding provided by industry may involve government moneys (up to 50 percent) if the work qualifies for national need status. Additional sources for funds may be the AIF, VDW, and foundations.

The manufacturing research effort is not solely dependent upon projects provided by industry, however. Independent research is also evident, with financial support from DFG and foundations. Generally, doctoral research is found in this category.

Industrial associations may also find it beneficial to establish research institutes at universities. These institutes, although staffed and funded by the associations, become firmly attached to an academic institute with similar orientation, and are administered by the director of the academic institute. The institutes generally share common facilities, and the industrial institute participates in academic activities such as offering courses and university-related research. It is interesting to note that the industrial institute is referred to as an institute at, while the academic institute is an institute of the university. An example of such an institute is the Research Station for Drop Forging (*Forschungstelle Gesenkschmieden* - FGS) established by the German Drop Forging Association (*Verband Deutscher Gesenkschmieden*) at the Technical University Hannover [12]. The FGS is funded 50 percent by the Drop Forging Association and 50 percent by DGF and AIF.

Overhead - Due to the independence of the university institute, the financial and administrative aspects of research are quite simple. The university needs no research office. The professor is his own research director, and is in sole charge of obtaining and administering research. Overhead costs can thus be kept quite low, since they have to support the institute only. It appears that no overhead charges may be attached to government research funds, and the institute may thus have to go back for additional money in case of cost overruns. Nominal overhead charges are included in industrial research contracts, however, so that the institute budget remains in the black. It is also accepted practice for the professor to pocket a small percentage of the contract funds for his own personal, unrestricted use.

Computer Use - The institutes visited had access to excellent computer facilities, which usually had at their hearts Univac and CDC machines. Liberal use appears to be made of this capability in the research effort. In addition to CAD/CAM applications, data are frequently reduced and plotted directly by computer as they are generated in the laboratories.

D. Concluding Remarks

It may be of interest to indicate some of the attitudes towards the system as they came to our attention, while in Germany.

There appears to be general satisfaction in industrial circles with the existing research arrangements. Industry also appears to be satisfied with the quality of the engineers coming from the universities. And yet, one professor visited at the Technical University of Hannover wondered if the engineers graduated from the universities were getting enough of a theoretical background to tackle the engineering problems of tomorrow. A survey of the German machine tool industry in 1972 by the VDW [13], seems to underscore this concern. For example, 100 percent of the companies polled felt that continuing education was necessary for their engineers and administrators. Ninety percent gave top priority to the study of new fundamentals. The topics receiving highest percentages were Design (mechanics, dynamics, rheology, theory of metal removal) with 86 percent and production control, programming of N/C machines with 83 percent. No need was seen to brush up on mathematics, however, since this topic received only 14 percent. The number of semester hours set aside for mathematics in the M.E. curriculum of the University of Stuttgart (See Table 1) seems to bear out the satisfactory math background.

The structure of the German university has also come under attack, especially the strong institute director. It is not surprising that delegations of German educators have returned from visits to U.S. campuses fully convinced that the American system is the one that should be adopted by Germany. Presently, university reforms are under way in Germany, but their thrust appears to be yet unclear, at least to the uninvolved observer. There is fear on the part of the professors, that the *Institut* will be eliminated. And yet, the Institute for Machine Tools and Manufacturing of the Technical University of Berlin, for example, emerged from reforms virtually intact. What has taken place there is modification instead of elimination. The institute has gained an additional professor and an assistant professor, but its administration remains in the hands of its director, the *Ordinarius*.

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13. Results of VDW Industrial Survey Presented at HGF Meeting in Konstanz, 1972.

FROM: C. H. Kahng
G. L. Scofield

SUBJECT: Trip Report
University Visits in Japan and Korea

The following report is divided into three main parts. The first part develops general information on engineering education in Japan which is typical for most universities. The second part is really a series of individual reports on specific visits in Japan. The third part contains information on Korea.

I. Engineering Education in Japan

Secondary education is similar to that in the United States. To enter college a student must pass an entrance examination. This examination is unique for each institution and is difficult. Students often take the exam several times before passing. Engineering students often act as tutors for the entrance exam. The exams are given on different dates to allow a student to seek entrance at second and third choice universities. Entrance exams are also used at the advanced level. Engineering students have a general studies program during the first year and study in the Faculty of Engineering thereafter. The Faculty of Engineering is headed by a dean and is divided into departments. Each department has several chairs, usually about 6-8.

Each chair includes a full professor, an associate professor or assistant professor, lecturers, and technical support staff. Programs are quite basic but all students do a research thesis during their senior year. Attrition is very low. It is not possible to transfer between universities in Japan. Very few non-Japanses students attend the universities and usually are not eligible for a degree. The semester system is common. Study at the graduate level is quite common. Financial aid for graduate study is available to less than half of all M.S. students ($60/mo) and to nearly all doctoral students ($120/mo). The financial aid is frequently in the form of a loan to be repaid after graduation. Financial aid comes from government and industrial sources. Research support comes as a budget from the government to each chair ($15,000 - $20,000 typical) and additional support comes from organizations representing a consortium of industries. The doctoral programs are primarily research oriented and as a result it is possible for an industrial researcher to achieve a doctorate with little or no formal university activity. Research areas are carefully divided up to avoid duplication. Research emphasis is on long term objectives. The idea of research by reason of a formal proposal was very uncommon. Industrial experience for faculty and/or students is the exception rather than the rule. Direct industrial interaction is not common although equipment grants are evident.

II. Individual Institutions - Japan

1. University of Tokyo
Monday, October 22, 1973

  a. Prof. Dr. Sogo Okamura
  Dean, Faculty of Engineering
  (elected every two years)

  General information about Tokyo University.

  b. Prof. Dr. Toshio Sata
  Department of Precision Machinery Engineering

  Tour of metrology (air conditioned) and adaptive control of machine tools laboratories.

  c. Prof. Dr. Nario Takenaka
  Department of Mechanical Engineering for Production

  Lab visits included adaptive control by force measurement and surface grinding. Associates were conducting soil mechanics (Dr. Hatamura) and powder metallurgy (Dr. Nagao) research.

Almost all faculty have the Ph.D. and are graduates of Tokyo University. Some faculty have industrial experience but it is uncommon. 150 chairs; 1,200 undergraduates in engineering; 20 departments; 80 - 90% of curriculum fixed; average student load - 17 credits/semester; no paid student assistants, graduate teaching assistants, or research assistants; about 1/3 of B.S. graduates study at M.S. level (two more years); 1/2 of M.S. graduates study at Ph.D. level (three more years).

2. Keio University
   Tuesday, October 23, 1973

   a. Prof. Dr. Takeyoshi Mori
      Dean, Faculty of Engineering

      General information on Keio (Professors Ando, Yonetsu, and Inazaki).

   b. Prof. Dr. Sakae Yonetsu

      Visited lab projects in precision feed mechanisms, surface roughness (EDM), and centerless grinding.

   c. Prof. Dr. Ichiro Inazaki

      Hydrostatic bearing research.

   d. Prof. Hasui

      Plasma and friction welding research.

   e. Prof. Sato

      Visited a special video assisted lab in mechanical drawing.

Visited other laboratories, classrooms, and the library. Keio is a high quality institution whose private status leads to larger classes, less obvious attention to the "chair" system and a general atmosphere more like a university in the United States. A greater variety of research was evident, including some duplication with national universities. Engineering enrollment 3,500. All faculty have Ph.D., most faculty graduated from Keio University. 30% of students earning B.S. go on to graduate study. About 100,000,000 yen research per year - over 50% from industry.

3. Tokyo Institute of Technology
   Wednesday, October 24, 1973

   a. Prof. Dr. Eiji Usui
      Mechanical Physics Department

      Visited laboratory supporting basic research on chip formation.

      Dr. Usui conducted us on a tour of the precision machinery and electronics laboratory where research was being conducted on screw threads and precision gear manufacturing. We also visited the machine tools laboratory of Dr. Ito and Dr. Matsuko.

Our visit was concluded by a conference attended by Dr. Eiji Usui (Mechanical Physics), Dr. Masanui Masuko (Production and Machine Tools), Dr. Yoshiro Anno (Precision Gear Manufacturing), Associate Professor Yoshimi Ito (Machine Tools), Associate Professor Jiro Otsuka (Precision Lead Screws and Grinding), and Associate Professor Jiro Ishikawa (Precision Gears). The general atmosphere at Tokyo Institute of Technology was that of a research institute rather than a university. From 30 to 50% go on to graduate study at the M.S. level with about

25% of the M.S. graduates going on to Ph.D. They do accept some transfer students and allow student in upper half of class to enter M.S. program without examination. Number of graduate students fixed by quota. Some industrial experience for student counts for laboratory credit. Research is applications oriented. Research support is from government.

4. The Institute of Vocational Training
   Thursday, October 25, 1973

   a. Dr. Takesi Sugeno
      President of the Institute
      (Formerly Dean of the Faculty of Engineering
      at Tokyo University)

      Dr. Sugeno expressed the need for engineering education in Japan to be more applications oriented in response to industrial needs.

   b. Prof. Naoharu Kinoshita

      Conducted us on a general tour of facilities at the new campus, including classrooms, laboratories, and library. We visited Professor Kinoshita's lab for research in wood working processes.

   c. Prof. Noboru Shinozaki

      Toured new laboratory for material removal, including N/C machining, metal forming, foundry, etc. We observed a number of special projects completed by students.

   d. Mr. Toshio Ishikawa, Chief
      International Cooperation Division

      Told us about the mission of his division in extending vocational studies, through the training of teachers, to underdeveloped countries.

This Institute is under the Ministry of Labor rather than the Ministry of Education. Their mission is to train teachers in the vocational area for teaching in schools and industry. The new campus has outstanding facilities and equipment (30 million dollars). Industrial interaction is strong. This is not an engineering college and does not emphasize research.

5. Nippon Steel Company
Friday, October 25, 1973

a. Mr. Hideshi Sato
General Manager
Technical Information Office
Technical Development Department
R & D Bureau
Nippon Steel Corporation

Mr. Sato acted as host and interpreter.

b. Mr. H. Katsui
Nittetsu Kenzai Company

Wrote a paper on engineering education in Japan.

c. Prof. Shojiro Nomura
Sophia University

d. Dr. M. Tomota
Former President of Yokokawa Electric Company

e. Mr. T. Fukuyama
Executive Secretary
Japan Society for Engineering Education

The discussion indicated no deep dissatisfaction with engineering education in Japan. The feeling was that a more applied education, rather than the current very basic type, would be better for smaller industry. The B.S. engineer usually goes to work as a blue collar worker at about $300 per month. Co-op programs or sandwich programs would be welcomed by industry. More interaction would be beneficial from industrial point of view. Lifetime employment is a factor in providing time for on-the-job training.

6. Kyoto University
Monday, October 29, 1973

a. Prof. Dr. Keiji Okushima and Asst. Prof. Tetsutaro Hoshi

The above faculty conducted our visit and tour of the research laboratories for precision machine tool research and grinding research. The precision machine tool work was related to thermal sources of stress and the grinding research involved a system of vibration to achieve improved surface finish. Much student unrest has been evident at Kyoto. A major concern of the students seemed to be too great interaction between the University and industry, particularly the chemical industry. They were also opposed to rising military strength in Japan. About 40% of the M.S. students were receiving modest financial support. Students not in a hurry due to lifetime employment. The undergraduate program contains a controversial program of electives. Continuing Education was stopped by internal political force. Research areas are of interest to industry but do not compete with industrial research. University gets out when industry steps in. Government research money provided to each chair and supports facilities and equipment only.

7. Osaka University
Tuesday, October 30, 1973

a. Prof. Dr. Hideo Tsuwa and Assoc. Prof. Yoshihara Namba

Departments of Mechanical Engineering, Precision Engineering, and Production Engineering were related to our visit. The Faculty of Engineering (700 staff) is divided into 17 departments. A total of 3,000 undergraduate, 500 M.S., and 50 Ph.D. students are enrolled. Students pay tuition before taking entrance exam. Very few transfer students and only at graduate level. Plant visits are typical as in other universities. Typical teaching load for full professor is 4 hours of lecture per week. One exam is given each term. Salary levels were about $12,000 per year (12 mo.) for professors, $8,000 for associate professors. Faculty very active in professional society activities. Researchers tend to work alone and set their own direction.

III. Technical Education and Research in Korea

1. Korean Institute of Science and Technology
Thursday, November 1, 1973

a. Dr. Kyung Taik Chang, Head
Metalworking Laboratory

Toured new outstanding laboratories established with U.S. Government support and assisted by Battelle Memorial Institute. Pride and good housekeeping were evident. Technology transfer to emerging industries is the mission. Some success, particularly in electronics, was evident. The Institute operates with 40 laboratories and 672 staff. Graduate engineering education is provided by a unit associated with KIST. The researchers hold the Ph.D. degree and unlike Japan it was common for staff to have industrial experience as well as some education in such places as the United States or Germany.

2. Minister of Science and Technology
Republic of Korea

a. Dr. Hyang Sup Choi
Minister of Science and Technology

Dr. Choi discussed the thoughts of his office on the development of industry and education in a developing country. Industrial development is to focus on such things as electronics, shipbuilding, and chemical plants because of the ability to be competitive in world markets. He talked about problems of pollution, etc. The educational program must develop vocational skills as well as engineering at an appropriate level. Dr. Choi was previously in charge of KIST and feels that it is doing an excellent job of interacting with industry in research.

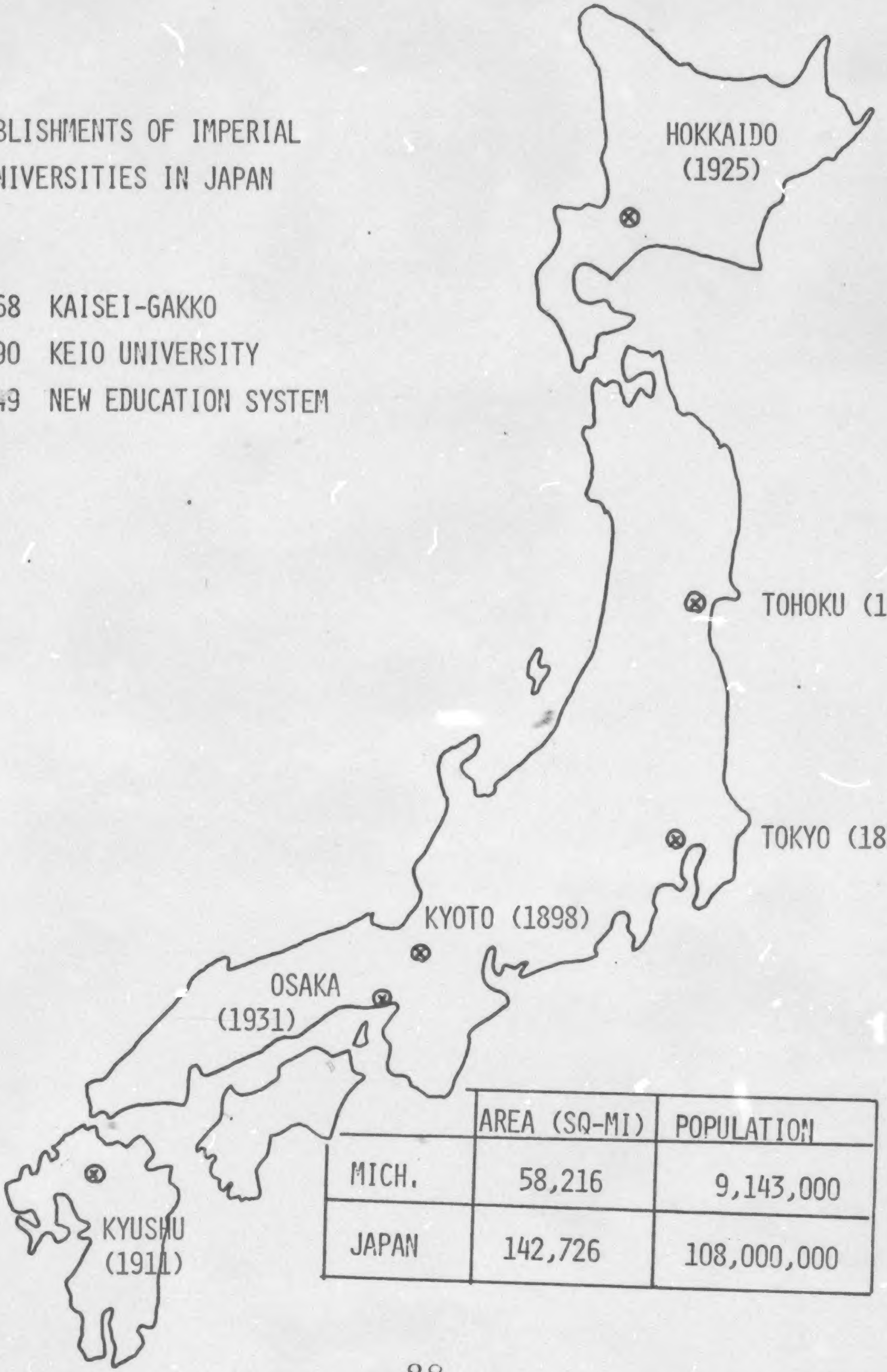
IV. Conclusion

This report does not attempt to give data or expanded descriptions of the institutions we visited. We did collect catalogs, descriptive literature, as well as technical papers from most of our visits. These resource materials are filed by institution and the available for those interested.

The overall impression of Japan and Korea is not the subject of this report; however, these impressions have been collected, along with photographs. Either of us would be happy to share this additional background information.

ESTABLISHMENTS OF IMPERIAL UNIVERSITIES IN JAPAN

1868 KAISEI-GAKKO
1890 KEIO UNIVERSITY
1949 NEW EDUCATION SYSTEM



	AREA (SQ-MI)	POPULATION
MICH.	58,216	9,143,000
JAPAN	142,726	108,000,000

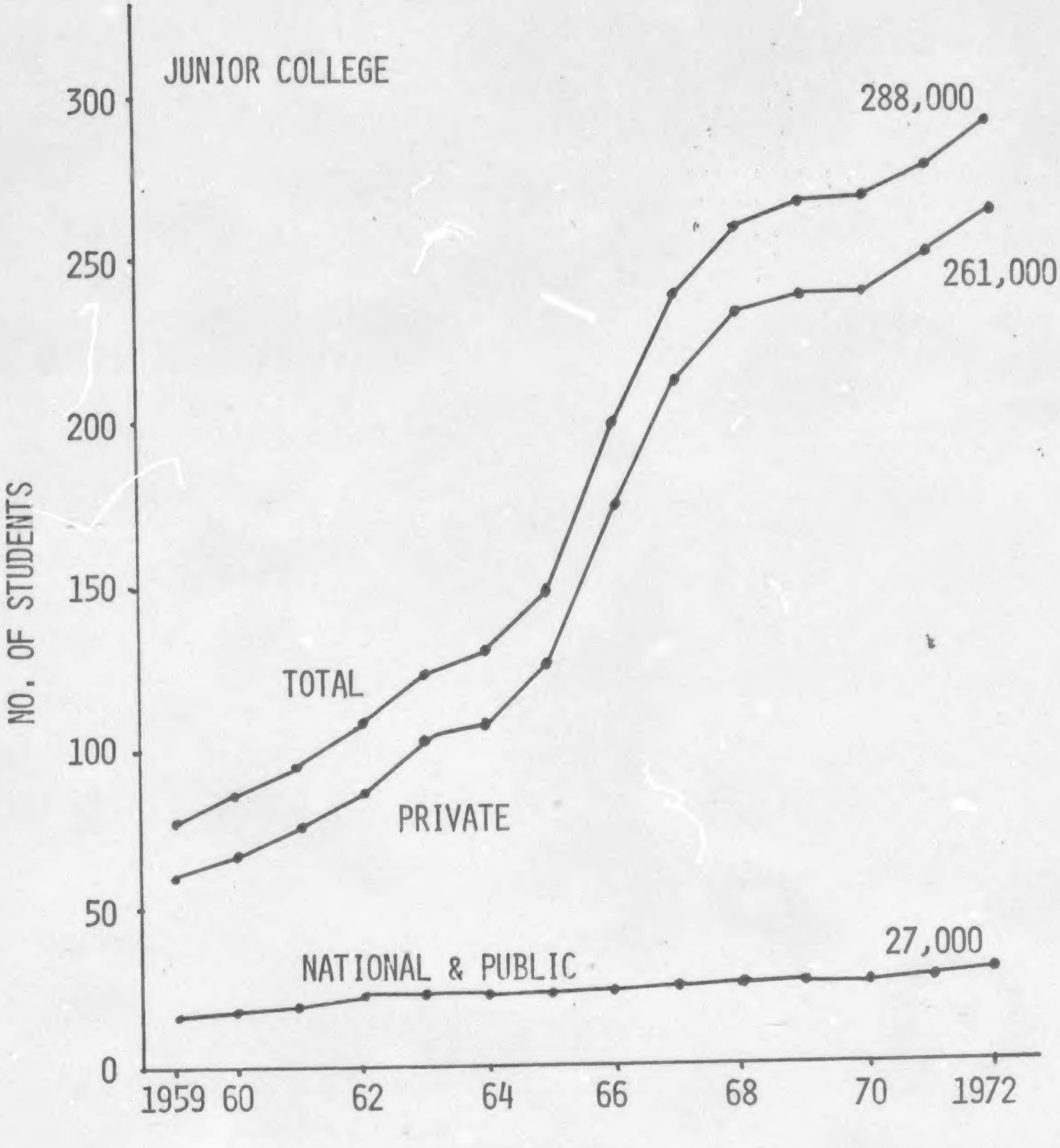
TOTAL NUMBER OF UNIVERSITIES AND JUNIOR COLLEGES IN JAPAN

(APRIL 1971)

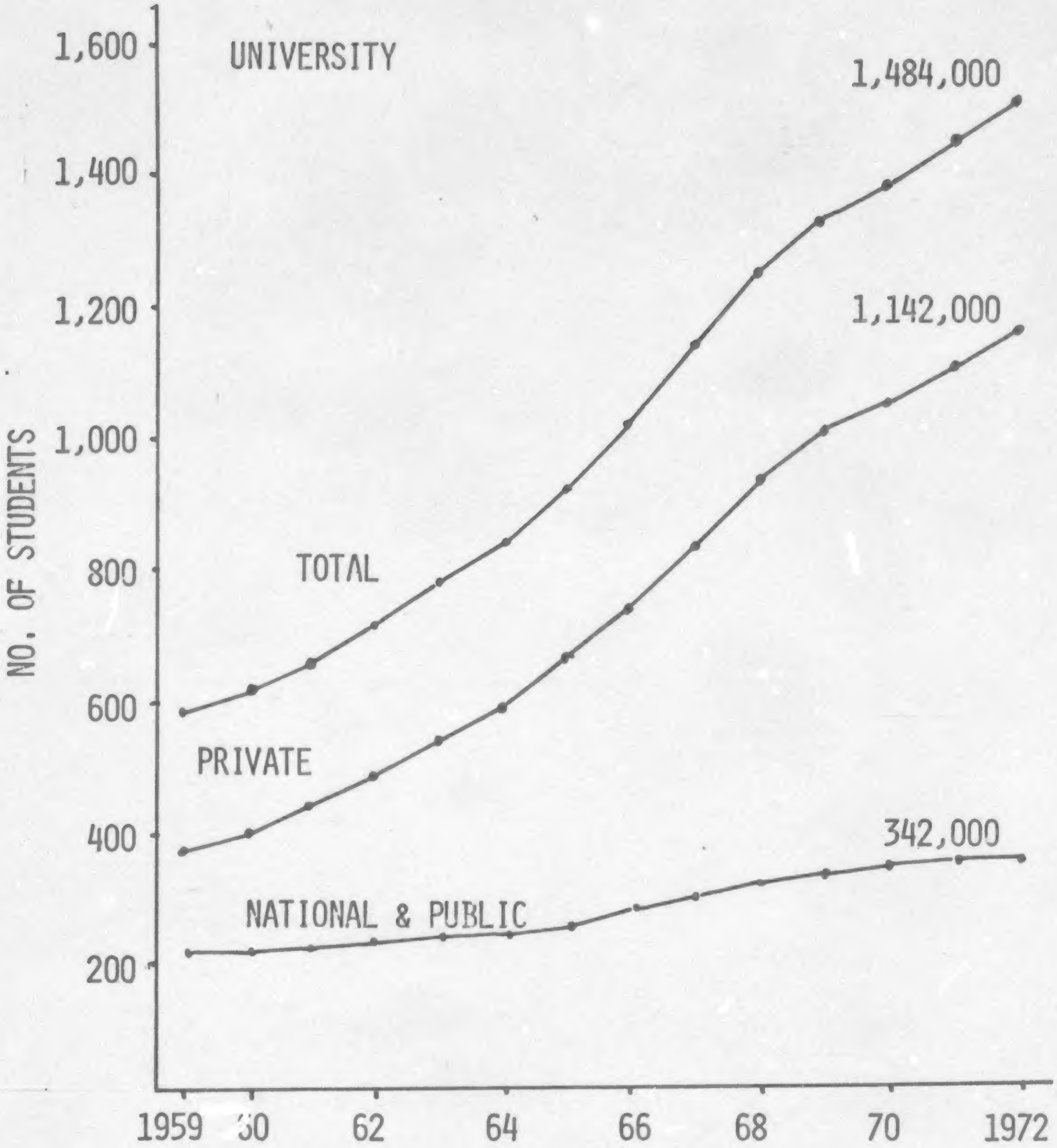
	UNIVERSITIES & COLLEGES	OFFERING					JUNIOR COLLEGES	TOTAL
		GRADUATE SCHOOL	EVENING COURSE	JUNIOR COLLEGE DIVISION	ADVANCED COURSE	SPECIAL COURSE		
NATIONAL	74 (2)	50	9	21	52	11	24	93
PUBLIC	37 (6)	18	5	2	4	--	39	76
PRIVATE	235 (67)	81	43	49	23	14	350	589
TOTAL	346 (75)	149	57	72	79	25	413	759

( ) UNIVERSITIES FOR WOMEN

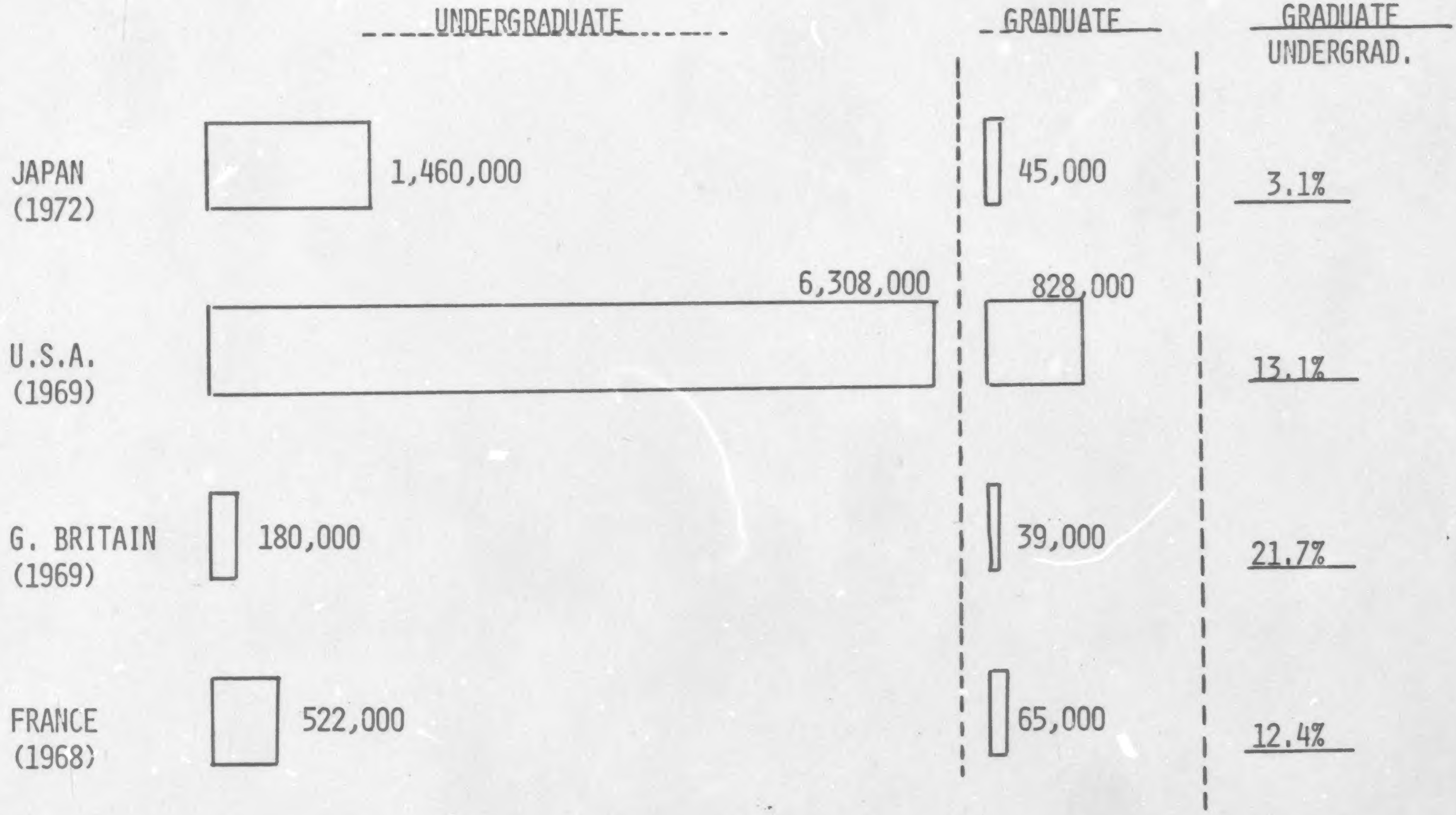
ENROLLMENT OF JAPANESE SCHOOLS



ENROLLMENT OF JAPANESE SCHOOLS



NO. OF STUDENTS (UNDERGRADUATE VS. GRADUATE)



FEATURES OF THE JAPANESE UNIVERSITY

1. SEMESTER SYSTEM:
   ENTRANCE EXAM PERIOD: MARCH - APRIL
   SUMMER SEMESTER: APRIL - SEPTEMBER
   WINTER SEMESTER: OCTOBER - MARCH
2. ALL UNIVERSITIES FIX THE NUMBER OF STUDENTS TO BE ADMITTED EACH YEAR. (≒40 STUDENTS/DEPARTMENT)
3. THE UNIVERSITIES PREPARE AND CONDUCT THEIR OWN ENTRANCE EXAMINATIONS.
4. THROUGH THE ENTRANCE EXAMINATION SYSTEM THE UNIVERSITIES CAN SELECT STUDENTS WITH QUALIFICATIONS MATCHING THE INSTITUTION.
5. NO INTER-UNIVERSITY TRANSFERS POSSIBLE.
6. VERY SMALL DROP-OUT/FAILURE RATE.
7. THESIS IS REQUIRED BEFORE BACHELOR OF SCIENCE DEGREE IS GRANTED.
8. MOST COMPANIES REQUIRE ENTRANCE EXAMINATIONS BEFORE HIRING PERSONNEL.

FUNCTION OF CHAIR IN JAPANESE UNIVERSITIES

1 - FULL PROFESSOR (DR.)
    4 HR LECTURE/WEEK
    REST RESEARCH
    SALARY $15,000/12 MONTHS

1 - ASSOCIATE PROFESSOR (DR.)
    4 HR LECTURE/WEEK
    REST RESEARCH
    SALARY $8,000/12 MONTHS

SEVERAL LECTURERS (DR.)
    PART TIME OR FULL TIME
    MAINLY TEACHING

SEVERAL ASSISTANTS (B.S., M.S., DR.)
    NO LECTURE
    LAB 8 HR/WEEK
    RESEARCH - THESIS SUPERVISION
    SALARY $6,000/12 MONTHS

STUDENTS: DR.E - CANDIDATES
M.S. - CANDIDATES
B.S. - CANDIDATES (SENIOR)

DEPARTMENT OF PRECISION MACHINERY ENGINEERING
THE UNIVERSITY OF TOKYO

CHAIRS:

1. MECHANICS FOR PRECISION MACHINERY
   (PROFESSOR DR. MIYAMOTO)
2. ELEMENTS OF PRECISION MACHINERY
   (PROFESSOR DR. JIMBO)
3. ENGINEERING DIMENSIONAL METROLOGY
   (PROFESSOR DR. UYEMURA)
4. DYNAMIC BEHAVIOR OF PRECISION MACHINERY
   (PROFESSOR DR. FUNAKUBO)*
5. MATERIAL PROCESSING IN PRECISION ENGINEERING
   (PROFESSOR DR. SATA)
6. PRODUCTION OF PRECISION MACHINERY
   (PROFESSOR DR. KINOSHITA)
7. MATERIAL FOR PRECISION MACHINERY
   (PROFESSOR DR. MIYAMOTO)

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* CHAIRMAN OF THE DEPARTMENT

EXCURSION PLAN
PRECISION MACHINERY ENGINEERING DEPARTMENT

	DATE	PLANT	PRODUCT
1	5/ 8/73	NIPPON SEIKO	BEARING
2	5/22/73	FUJITSU - ELECTRIC	N/C SYSTEM
3	6/ 5/73	CITIZEN WATCH	WATCH
4	6/19/73	NIPPON - STEEL PIPE	STEEL PIPE, WELDING
5	7/ 3/73	INSTRUMENT LABORATORY	PRECISION MEASUREMENT
6	9/11/73	NIPPON - OPTICS	OPTICAL INSTRUMENTS
7	9/25/73	NISSAN AUTOMOBILE CO.	PRESS WORKING ASSEMBLY LI
8	11/12/73	YAMATAKE - HONEYWELL	AUTOMATIC CONTROL
9	11/19/73	NHK - LABORATORY	VIDEO & AUDIO FACILITIES
10	11/16/73	TOSHIBA ELECT. CO.	PRECISION MACHINING
11	12/ 3/73	OBAN - PRINTING CO.	PRINTING MACHINE
12	1/21/74	GOVERNMENTAL MECHANICAL RESEARCH LABORATORY	MACHINE TOOLS METAL CUTTING

INTERACTION BETWEEN UNIVERSITIES AND INDUSTRY

1. PLANT AND INDUSTRIAL TOURS ARE ARRANGED FOR STUDENTS.
2. SUMMER EMPLOYMENT IS FREELY OFFERED TO STUDENTS BY INDUSTRY.
3. EXCHANGE OF LECTURERS BETWEEN UNIVERSITY AND INDUSTRY.
4. RESEARCH SPONSORED BY INDUSTRY.
5. ENGINEERS FROM INDUSTRY AUDIT NEW COURSES.
6. PROFESSORS ARE ALWAYS READY TO ASSIST THEIR FORMER STUDENTS.
7. THROUGH THE ACTIVITIES OF ACADEMIC SOCIETIES OR PERSONALLY, UNIVERSITIES AND INDUSTRY WORK TOGETHER IN FURTHERING RESEARCH AND DEVELOPMENT.
8. PROFESSORS ARE VERY CONCERNED ABOUT FINDING EMPLOYMENT FOR THEIR STUDENTS (LIFE EMPLOYMENT).
9. INDUSTRY PARTICIPATES IN A NATIONAL LONG-RANGE RESEARCH PROGRAM.

SOURCES OF RESEARCH MONEY

1. GOVERNMENT

   $15,000/YEAR FOR ONE CHAIR
   ONLY FACILITIES AND MATERIALS
   SALARIES EXCLUDED

2. ACADEMIC SOCIETY + GOVERNMENT + INDUSTRIES

   RESEARCH PROJECT COMMITTEE SELECTS INSTITUTION
   EXAMPLE: AUTOMATIC MAINTENANCE OF MACHINE TOOLS
   $100,000/YEAR
   10 UNIVERSITIES

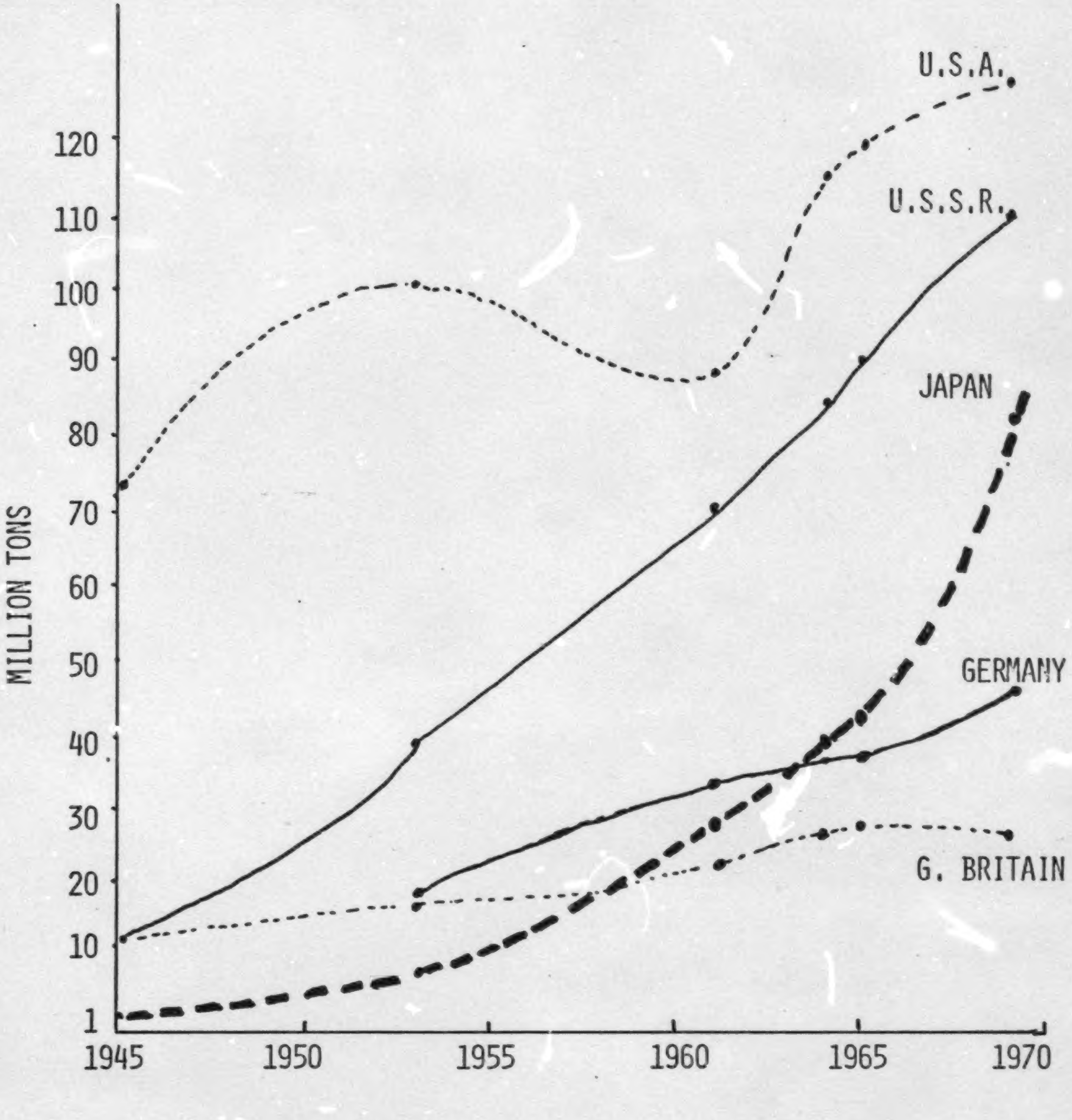
3. INDUSTRY

   NOT DIRECT
   THROUGH ORGANIZATION
   PROFESSOR TOKENAKA, TOKYO UNIVERSITY $30,000/YEAR

4. ENTRUST RESEARCH FROM INDUSTRY

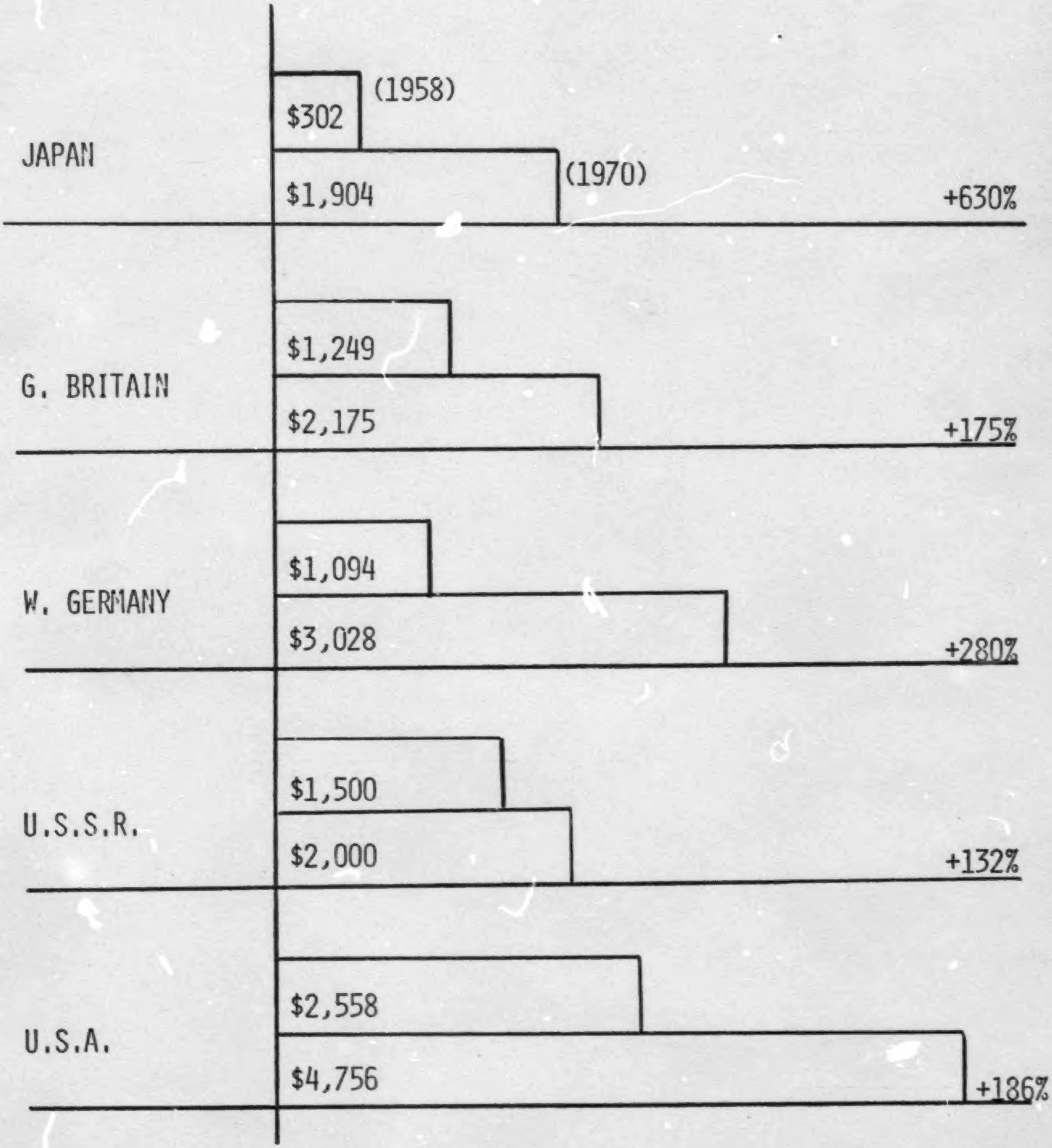
   PERSONAL AND FACILITIES COME FROM INDUSTRY

STEEL PRODUCTION



PER CAPITA G.N.P.

(TIME, MARCH 12, 1973)



4. REPORTS ON SYMPOSIA CONDUCTED AND ATTENDED

PROCEEDINGS OF THE SYMPOSIUM HELD IN DEARBORN
December 12, 1973

A symposium intended to advertise as well as discuss the proposed internship program was held on December 12, 1973 (see enclosed program). A large number of brochure-type invitations were sent to Michigan and other Midwest industries. Although the response was light, the symposium was a success, since a relatively small attendance had the advantage of promoting free and constructive discussion.

The subjects presented by the speakers were as follows:

Robert Colton described the structure behind the NSF Experimental R&D Incentives Program. The ERDIO (Experimental R&D Incentives Office) was shown to be divided into the Public Sector Office, the Experimental Design and Evaluation Staff Office, and the Private Sector Office.

The objectives of the ERDIO are to stimulate increased non-federal investment in R&D and to improve the climate for technological innovation. Technological Innovation is defined as "the first use of science and technology in a new way in the U.S. economy with commercial success."

Other significant points dealing with ERDIO policies and procedures are: Federal Incentives for Technological Innovation are broken down into Government markets for technological innovation (procedures for non-civilian and government needs) on one hand, and Government stimulation of factors causing technological innovation in the private sector on the other. The Private Sector program elements are indicated to be: Synthesis of technological innovation factors, co-op research incentives, development of human resources, financial incentives, market incentives, and regulatory related incentives. The objective of the Private Sector Office is to identify and test incentives that stimulate the factors effecting technological innovation.

· Examples of possible Government incentives are classified as direct (government market, government contracts, government subsidies) and indirect (low interest loans, loan guarantees and insurance, tax deductions, etc.).

Development of human resources has as its aim an increase in quantity and quality of technological entrepreneurs and innovators from the universities, and an increase in the utilization or commercialization of university, business, and community held technology. Output variables include the number of students becoming entrepreneurs or innovators and their success, and the number of ideas, new products, processes, patents and inventions resulting from this effort.

Experiment development for evaluation and testing of incentives involves these steps:

- Background studies - evaluate incentive
- Conceptual design of experiment to test incentive
- Exploratory experiment to test incentive in a limited role
- Full experiment to test incentive by developing quantitative data to evaluate effectiveness and suitability of incentives
- Recommendations to administration regarding relative suitability of various incentives

Dr. M. Eugene Merchant's presentation dealt with the topic "The Status Quo is not the way to go, this is not where the action is". Major factors controlling human and technological activity developed from authoritarianism in the past to tested thought at present, but will require creative innovation in the future, he stated. The effects of creative innovation on technological progress are the breaking of barriers between disciplines, acceleration through systems simulation, and the replacement of conventional disciplines by multidisciplinary engineering domains such as manufacturing engineering.

The computer integrated manufacturing system (CIMS) was cited as being capable of providing a breakthrough in the quest for cost saving and increased productivity in the future. Its importance was underlined by the fact that 30 percent of the GNP is affected by manufacturing. Since such systems are very costly, their implementation provides a major challenge for university-industry interaction. In fact, broad cooperation is needed on a national scale.

A forecast into the future of manufacturing conducted by CIRP provided the following outlook:

- By 1980, a computer software system for full automation and optimization is expected to be in existence.

  By 1985, full on-line automation and optimization of complete manufacturing plants controlled by a central computer will be a reality.

  By 1990, more than 50 percent of the machine tools produced will not have a "stand-alone" use, but will instead be part of a versatile manufacturing system, featuring automatic part handling between stations, and being controlled from a central process computer.

Major cooperative ventures are already underway in Europe and Japan, where universities and industry have been joined by their respective governments in efforts to implement CIMS.

The steps towards achieving these goals were outlined to be

- Integrated manufacturing software systems
- Group technology or cellular manufacture
- Computerized N/C and Direct N/C
- Multi-station manufacturing systems
- The computer-integrated automatic factory

The kinds of interaction believed necessary are

- Cooperation between university and industry in manufacturing R&D coordinated on a national scale

- Universities are to provide means of coupling competitive industries without violating anti-trust laws

- Strengthened manufacturing engineering education

- Assistance from government, technical societies, for coordination of guidance and funding

University-Industry interaction in Germany was reviewed by K. J. Weinmann. A complete report of the findings is presented in ~~Appendix B~~. Chapter 3

University-Industry interaction in Japan was reviewed by C. H. Kahng. A complete report of the findings is presented in ~~Appendix B~~. Chapter 3

J. C. Gerdeen's description of the Internship Program appears in ~~Appendix A~~. Chapter 2

The luncheon speaker, R. William Taylor, stressed the need for closer university-industry ties, and praised the internship program proposed by Michigan Tech as being capable of strengthening cooperation.

The panel discussion was intended to bring out the pros and cons of the proposed program. It turned out, however, that no adverse criticisms of the program were raised. Due to the small size of the crowd, a very lively and frank discussion took place, during which a number of points were brought up, mostly dealing with implementation of the program. A significant part of the time was spent in stressing the importance of salesmanship in trying to convince the industrial and the academic communities of the value of this program. Michigan Tech drew praise from industry for trying to remove the blockage to a meaningful, productive exchange of ideas between university and industry.

Towards the end of the program, the questionnaire shown on the next page was filled out by 10 of the participants. From the response, it is clear that the Internship Program has met with substantial positive interest.

Name
Company or Affiliation

QUESTIONNAIRE

1. Does your company have a co-op program for students?

9 of 10 yes

2. Are co-op students better prepared for entry level jobs in industry? Why?

10 of 10 yes

3. Do you believe that the Internship Program is a worthwhile project to undertake for a trial period?

10 of 10 yes

4. Do you believe that the Internship Program will be better for the University, the student, and Industry than the co-op?

5 - better, 1 - equal, 3 - uncertain

5. Does your company sponsor research projects at Universities?

6 - yes, 3 - little or none

6. Is the present state of interaction between Industry and Universities satisfactory?

9 of 9 no

7. Do you consider current regular full-time engineering education satisfies the need for entry level performance in Industry?

6 - no, 3 - yes (qualified)

8. Please indicate the components of engineering education you feel need to be strengthened.

- Humanities and Social Sciences	2 of 9
- Basic Sciences (Chemistry and Physics)	0 of 9
- Mathematics	1 of 9
- Engineering Science (Statics, Dynamics, Thermo, etc.)	1 of 9
- Design Projects	6 of 9
- Laboratory Projects	5 of 9
- Practical Experience	6 of 9

Comments:

9. Would you recommend that your company participate in the Internship Program described at this symposium?

7 - yes, 2 - uncertain, 1 - upgrade co-op program

10. Would you recommend that your company participate (at some expense) in a project other than the Internship Program to improve University-Industry interaction?

7 - yes 1 - bring faculty to industry
1 - faculty exchange

MICHIGAN TECHNOLOGICAL UNIVERSITY
HOUGHTON, MICHIGAN

A SYMPOSIUM ON A STUDY TO IMPROVE UNIVERSITY-INDUSTRY INTERACTION IN MATERIALS PROCESSING

March 1, 1974

PROGRAM

8:00-8:45 am	Registration
8:45 am	SESSION I Chairman: Gordon L. Scofield Professor and Head ME-EM Department Michigan Technological University
8:45-9:00 am	1. Opening remarks, Chairman
9:00-9:15 am	2. Welcome and Remarks - President Raymond L. Smith Michigan Technological University
9:15-9:45 am	3. "The National Science Foundation R&D Incentives Program - Human Resources for Technology Development" ~~Evan Anderson~~ R. M. Colton Project Director National Science Foundation For R.M. Colton: J.C. Gerdeen
9:45-10:15 am	4. "Review of University-Industrial Interaction in Germany" Klaus J. Weinmann Assistant Professor Michigan Technological University
10:15-10:30 am	Coffee Break
10:30-11:00 am	5. "Review of University-Industrial Interaction in Japan" Charles H. Kahng Associate Professor Michigan Technological University
11:00-11:30 am	6. Presentation on the Internship Program James C. Gerdeen Professor Michigan Technological University
11:30-11:50 am	Discussion: Questions and Comments on Morning Talks

12:00 Noon 7. Luncheon
Speaker -"University-Industry Interaction in Engineering at Michigan Tech"
James A. Kent
Dean of Engineering
Michigan Technological University

For J. A. Kent:
C.E. Work,
Associate Dean

1:30 pm SESSION II
Chairman: Gordon L. Scofield

1:30-2:30 pm 8. Panel Discussion of "University-Industrial Interaction and Reactions to the Internship Program - Pros and Cons"

Panel: ~~Evan Anderson~~
~~Project Director~~
~~National Science Foundation~~

Marvin F. DeVries
Chairman
SME Education-Committee
University of Wisconsin-Madison

Gerald T. Underwood
Manager of Personnel and Management Development
Deere & Co.

Richard O. Lane
Director of Marketing
Frank Bancroft, Co.

Harold Ruf
Vice President
Grede Foundries, Inc.
Milwaukee

A. A. Hendrickson
Professor
Metallurgical Engineering
Michigan Technological University

2:30-3:30 pm 9. Discussion Groups

3:30-3:45 pm Coffee Break

3:45-4:15 pm 10. Report of Discussion Groups

4:15-4:30 pm 11. Summation of Symposium - What Now?
Gordon L. Scofield

PROCEEDINGS OF THE SYMPOSIUM HELD ON THE CAMPUS OF MICHIGAN TECHNOLOGICAL UNIVERSITY

March 1, 1974

Both purpose and format of this symposium were essentially the same as those for the Dearborn Symposium, as the program shows. Almost 40 persons attended the symposium, with half of the participants coming from industry. The locations of the companies represented ranged from the Upper Peninsula of Michigan to Troy, New York.

After welcoming remarks by Dr. R. L. Smith, President of Michigan Tech, Dr. Gerdeen outlined the Experimental R&D Incentives Program on behalf of Dr. Colton from NSF, who was unable to attend. Drs. Weinmann and Kahng again reported on university-industry interaction in Germany and Japan. Dr. Gerdeen's description of the Internship Program concluded the activities of the morning.

During the Luncheon, Dr. C. E. Work, Associate Dean of Engineering, presented an informative as well as entertaining account of the present status of the interaction of Michigan Technological University with industry.

The afternoon session was opened with the panel discussion, with each member providing constructive input to the proposed program. An open discussion involving all attendees ensued. Some of the remarks made were the following:

Mr. R. O. Lane emphasized the need to sell the Internship Program to most companies on an individual basis. It is important to make management see the need for what this program has to offer.

Dr. M. deVries developed a discrepancy model to describe the current status of university-industry relations. Criteria must be established to close the gap between existing situation and desired situations.

Mr. G. Underwood emphasized that since the return on investment depends to a major percentage on tooling cost, it is essential to shift the excitement among students from product design to processing techniques, i.e. manufacturing. He is emphatic in his view that the proposed program is not a co-op program: Interchange between university and industry makes it unique. Information flow to the university is particularly important, he feels. He also suggests that a change in nomenclature from Industrial Internship Program to TECHNOLOGY EXCHANGE PROGRAM may be appropriate, and may be better suited to help sell the program to industry.

Proprietary aspects were raised by the audience as a sensitive point which needs to be considered. Underwood retorted that companies generally have lots of projects in non-sensitive areas. These are the types of projects that have never been "gotten around to" due to lack of time, yet there might be profit plums among them. These projects would have the advantage of being relatively time-independent.

Dr. G. Dieter, Director of CMU's Processing Research Institute, added that concerns about sensitivity of a project can be diffused by building in appropriate safeguards. He cited proprietary work the PRI is currently doing for Xerox Corporation as an example.

Mr. H. Ruf of Grede Foundries, speaking for the foundry industry, stated that the industry has an image problem: it is considered to be dirty, and engineering graduates tend to shy away from it. He also expressed a need for management people, industrial and manufacturing oriented engineers and metallurgists rather than designers. Not much research is being done by the industry itself, but rather by trade and technical associations. What industry has are production problems. Also, OSHA, EPA, and Energy Crisis have created a need for technical people to help adjust to the changed picture.

Dr. A. A. Hendrickson spoke for the forging industry. The proposed program can achieve a lot for industry, he stated, since it has not been innovative. Research is not what is needed here, but instead, technology transfer. The forging industry must be made aware of existing technology. Presently, technical people are missing, since small companies cannot afford to hire qualified engineers (metallurgists). He suggests that the forging industry be approached as a body.

It thus appears that there is a trend towards manufacturing engineering activities in industry, and industry would like to see Michigan Tech provide them with the manpower that can cope with its problems. Since the objectives of this Internship Program are in agreement with these needs, it was generally warmly received by the participants. Industrial representatives in particular were appreciative of the fact that Michigan Tech shows an interest in helping industry. One hundred percent would recommend this program to their companies, as the attached questionnaire shows.

Name 14 Individuals Reporting
Company or Affiliation

QUESTIONNAIRE

1. Does your company have a co-op program for students?

8 yes, 5 no, 1 not applicable

2. Are co-op students better prepared for entry level jobs in industry? Why?

11 yes, 3 no opinion

3. Do you believe that the Internship Program is a worthwhile project to undertake for a trial period?

14 yes

4. Do you believe that the Internship Program will be better for the University, the student, and Industry than the co-op?

10 yes, 2 maybe, 2 not necessarily
Some feel it may benefit university faculty most

5. Does your company sponsor research projects at Universities?

8 yes, 4 no, 1 doesn't know, 1 not applicable

6. Is the present state of interaction between Industry and Universities satisfactory?

14 no

7. Do you consider current regular full-time engineering education satisfies the need for entry level performance in Industry?

5 yes (with reservation), 8 no, 1 no opinion

8. Please indicate the components of engineering education you feel need to be strengthened.

- Humanities and Social Sciences	5
- Basic Sciences (Chemistry and Physics)	2
- Mathematics	1
- Engineering Science (Statics, Dynamics, Thermo, etc.)	4
- Design Projects	4
- Laboratory Projects	2
- Practical Experience	12

Comments: Need more manufacturing education, students need better training in communication, need development of character and leadership

9. Would you recommend that your company participate in the Internship Program described at this symposium?

13 yes, 1 not applicable

10. Would you recommend that your company participate (at some expense) in a project other than the Internship Program to improve University-Industry interaction?

9 yes, 2 maybe, 2 no opinion, 1 not applicable

REPORT OF TRIP TO CARNEGIE-MELLON UNIVERSITY
December 4, 1973
by J. C. Gerdeen and K. J. Weinmann

J. C. Gerdeen was invited to participate in the "Workshop on Research and Educational Needs in the Pressure Vessel Piping and Related Industries" held at CMU, and sponsored by NSF and the Processing Research Institute of CMU. Due to some common features between PRI and to the Industrial Internship Program, K. J. Weinmann accompanied J. C. Gerdeen to CMU, so both could discuss the programs with G. E. Dieter, Director of PRI, and attend the workshop which dealt directly with university-industry interaction.

The workshop brought together representatives from industry, universities, government, trade associations, and foundations to discuss needs of the pressure vessel industry, both in engineering manpower and research. The need for course work and research at the universities relevant to the industry, and the need for closer relationships between practicing engineers in industry and university professors were stressed. Since the different backgrounds of the participants resulted in different ideas, lively discussions took place. When the workshop adjourned, no noticeable consensus had been reached regarding workable solutions to the problem of how to improve the working climate between university and industry in this particular area of engineering.

The private discussions with G. E. Dieter and M. C. Shaw, Head of the Department of Mechanical Engineering of CMU were fruitful, since they helped to clarify some questions regarding PRI. Also, the two gentlemen assured us of their willingness to cooperate with the Michigan Tech efforts, and to share with us their experience gained in their efforts to establish mutually beneficial relationships with industry.

The Processing Research Institute, which involves the Departments of Chemical Engineering, Mechanical Engineering, and Metallurgy and Materials Science, offers a Master of Engineering Program designed to prepare the student professionally for an engineering career. Graduate students are given industrial projects, for whose successful completion they have the major responsibility. Each project is directly supervised by PRI faculty members, but also receives input from engineering experts from industry.

Currently PRI works with 15 companies outside the Pittsburgh area. The working arrangement with each firm is as follows: A research project involving graduate students, is funded 50 percent by the company and 50 percent by NSF the first year. After that, it is fully funded by the company.

A REPORT ON THE
NATIONAL CONFERENCE ON MANUFACTURING TECHNOLOGY AND PRODUCTIVITY

held at

Massachusetts Institute of Technology
Cambridge, Massachusetts

on

December 11 and 12, 1973

by

R. W. Kauppila
Mechanical Engineering-Engineering Mechanics Department
Michigan Technological University
Houghton, Michigan 49931

INTRODUCTION

A National Conference on Manufacturing Technology and Productivity was held at the Massachusetts Institute of Technology, Cambridge, Massachusetts, on December 11 and 12, 1973. The purpose of this conference was to create an exchange of information and opinion among industrial leaders and university faculty who share a desire to revitalize U. S. industry. The following report is a summary of the discussions that took place during this conference. All written information that was provided at the conference is included. Although a summary of the entire conference proceedings was repeatedly requested by many of the attendees, only write-ups of the workshop reports were provided.

The conference was attended by over one hundred representatives of industry and universities. It should be noted that this conference was primarily attended by upper management from industry with 83 of the preregistered attendees representing companies or government agencies.

Fifteen presentations were made by leading authorities in their fields of interest. The following is a brief summary of each presentation.

"Introduction to the Conference"

Nathan H. Cook, MIT

Dr. Cook welcomed the conference attendees. He noted that the conference was attended by well over one hundred attendees including one woman, almost all of whom came from industry. (The one woman was discovered to be from the press.) Dr. Cook described the conference as divided into three parts. The first part was a number of talks on the social and economic climate for our manufacturing industries. The second part was a presentation of technological innovations for the future. The third part was workshops which would allow the attendees to express their opinions and thus provide their input to the conference. Dr. Cook mentioned that the conference had been one year in planning.

"Welcoming Remarks"

Howard W. Johnson, MIT

Mr. Johnson officially welcomed the conference attendees, presented a history of MIT, and described the direction of their efforts.

"Recent Productivity Trends and the Changing Socio-Economic Environment"

John W. Kendricks, The George Washington University

Dr. Kendricks' talk covered several related points. Indices of productivity were briefly discussed. Productivity increases require investments. Unionization decreases productivity. Productivity level in U. S. is still the highest in the world but other countries are catching up. Lower educational enrollments are poor for increased productivity. Economic growth for 1974 is expected to be approximately 1% lower than normal. Labor force growth, which provided part of past productivity growth, has peaked. Economy shift has been to services where 60% of today's working force is employed and where contribution to productivity increase is poor. Competitive forces will give more productivity which will lead to more productivity bargaining and profit sharing. Government intervention will increase and cause lower productivity. Energy crisis will change legislators' actions which should help productivity. Wage and price controls distort productivity picture. Looseness of values and attitudes, negative social tendencies and adverse political tendencies have been detrimental. Outlook for future is positive but not dramatic.

"Technological Innovation in Manufacturing"
Jordan J. Baruch, Harvard

Dr. Baruch changed his title to "Management of Technological Advances". He had several interesting examples of gaging productivity. One example compared light bulbs. A light bulb price has increased from 28¢ in 1950 to 33¢ in 1970 indicating not much productivity increase when adjusted for inflation. However, if measured in terms of output in million lumen hours (MLH) the corresponding total cost including power has gone from $2.60 to $1.30 per MLH. If fluorescent lighting is included, the cost has gone from $2.60 to 31¢ per MLH. This service cost is more reliable than unit cost and should be used for measuring productivity. The changes in these products involved technological advances.

Technological advances take place as a result of several activities. They are defined as recognition, definition, implementation, conveyance (marketing), evaluation, advocacy (organized process of lying) and holding (doing nothing really - "keep it on the back burner"). The last activity, holding, is used when an advance is premature. These activities are all involved to varying degrees in bringing forth a technological advance. Managers manage these activities.

"Design Priorities and External Costs"
David G. Wilson, MIT

Dr. Wilson presented a humorous talk on design priorities and their costs. One example was the priority assigned to the design of a clean automotive exhaust. When the dirty exhaust blew out into open space, the priority was low. When the exhaust engulfed pedestrians, the priority was more acute. When the exhaust was piped back into the car, the priority was very acute.

"Productivity, Science and Technology"
J. Herbert Hollomon, MIT

Innovation and diffusion of technology is the key to improved productivity. This is clearly seen in U. S. agriculture where government extension agencies played an important role. Today, U. S. agriculture production leads the rest of the world. Why can't this be done for our manufacturing industries?

The U. S. government has placed its efforts on space and arms with no emphasis on industrial products. Western European and Japanese governments have concentrated on industry and products of consumption.

Technology changes are necessary but usually costly and risky. If sudden, they impair rational decisions and cause unfavorable displacements of employees. U. S. managers generally desire no changes. Japan has a policy of "cannot lay anyone off" which prohibits displacement. France and England have a tax that covers retraining, reeducating and relocating workers.

"Productivity in Education"
Paul E. Gray, MIT

Productivity in education has not increased dramatically. It cannot be measured by today's "$ per credit hour". Content is what should be counted. Education is an individual effort on the part of the student which defies any real measurement of productivity.

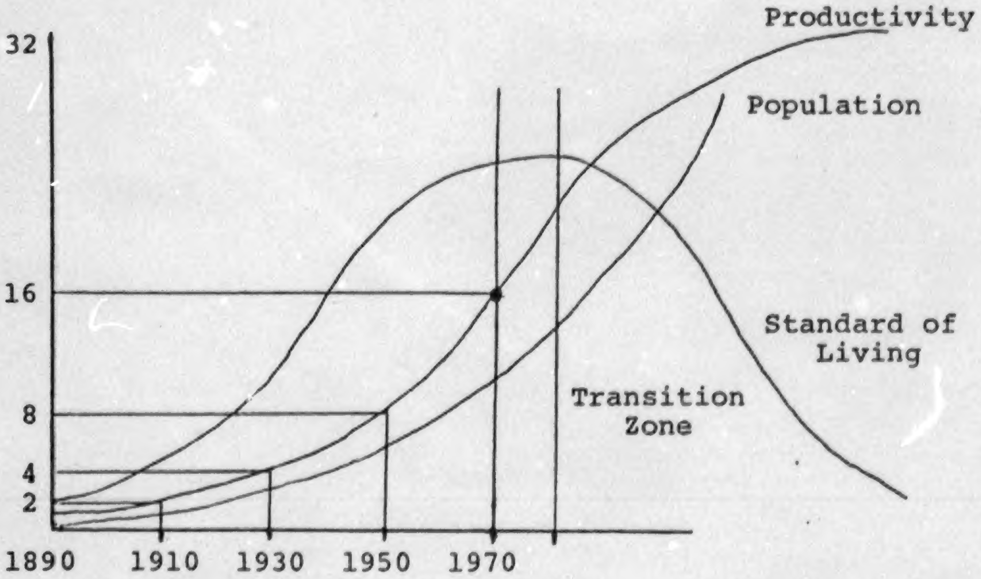
"Human Factors in Manufacturing"
Charles A. Myers, MIT

The most difficult but most important job of management is managing man and all else depends on it. The factors that influence this management are communication, information, etc. which are the human factors in manufacturing.

"1980-2000 The Future for Manufacturing Industries"
Jay W. Forrester, MIT

The most informative and interesting talk was given by Dr. Forrester. By use of data from his text "World Dynamics" he presented a gloomy outlook for the future. (Following this talk, sales of his book in the CO-OP, MIT's bookstore were brisk and exhausted their available supply.)

Dr. Forrester showed that all dynamic systems follow a growth curve consisting of a doubling of growth in increments of time. When the transition point is reached, the system is half grown with only one more possible doubling of growth. Productivity in the U. S. appears to follow this curve with the transition in productivity occurring in 1970 (earlier than expected). The growth in U. S. population also follows a similar curve but has not defined a clear transition point yet in spite of zero population growth efforts. When the productivity is divided by the population and graphed, the result is an index of standard of living curve. All three of these curves are shown in the figure below.



It appears that we are today in the transition zone. In the transition zone, close coupling should take place. This is in evidence today for example, with the automobile enmeshed in environmental and energy crisis controversy with political overtones. If the population growth can be curbed and productivity maintained, then the standard of living can be maintained. However, can productivity be maintained with our current energy shortage?

Can we get more energy? Can the oil shales do the trick? Rumor has it that energy production takes 20% of the productivity dollar. It is reported that shale oil will cost five times that of current energy. Conclusion is that it cannot be done, not from shale oil.

How did we get to where we are today on productivity curve? We accumulated capital strength and production at a low cost with past workers receiving little enjoyment for their efforts.

Severe problems are coming up. Expropriation of foreign operations is certain. Cuts in our nonproductive efforts will have to be made. All overhead items will have to go. Fifty percent of higher education must go. Fifty percent of financial people must go. No new construction will really take place. Large numbers of service industries will disappear. (The service people should go back to agriculture.) The following changes will thus occur:

1. Reversal of capital expansion
2. Shift out of white collar class
3. Less education
4. Research productivity will drop even more
5. Longer life products will come (throw away at end)
6. Large throughput will be cut down (make new rather than repair existing is a horrible drain on resources)
7. National economy will go down

A shorter work week is proposed in industry. At a time when 40% are in a productive activity, how much can the system stand before the mischief of the effect catches up?

Will technology pull us out? In spite of tremendous food advantages, we have a food crisis. In spite of energy technology, we have an energy crisis. If we do not pull out but follow the curves, an example of the end exists today for everyone to see. India reached its peak 800 years ago. Theirs is a model of what we can expect at the end. A sobering parting thought is visible in Massachusetts. The current population density in Massachusetts is one-half that of India today. Is one more doubling the end? Then what?

"Teleoperators/Programmable, Adaptable Assembly Systems"
James L. Nevins, MIT
Thomas B. Sheridan, MIT

Mr. Nevins talked about past and recent man-machine systems. A movie of an automated water pump assembly was shown. Movies of manipulator operations with feedback sending controls were also shown. The problems associated with "teaching" a computer-controlled manipulator to drop a bolt into a hole were briefly discussed. It was shown that when obstacles are placed in the way, a complex learning process must be undertaken. It became very evident that the first "teaching" process could be very frustrating and that the logical learning process which we take for granted is not a simple computer programming exercise.

Dr. Sheridan made a humorous presentation of the problems associated with writing computer programs for man-machine systems. The objective he chose was to direct the machine to paint a block of wood with the paint in a can. By use of several humorous slides, he showed many different interpretations that could be given to the command PAINT THE BLOCK. It became obvious that the programmer would have to prepare a set of instructions that were much more detailed than that which one would give to a pre-schooler.

"High Volume Manufacturing Technology"
F. Keith Glock, MIT

Mr. Glick described the use of a computer aided graphics facility in designing a crankshaft counterweight and in determining the resulting center of gravity and other engineering data.

"New Developments in Manufacturing Processes"
Nam P. Suh, MIT

Dr. Suh described a number of new developments in manufacturing processes at MIT. The brief talk described development of five new types of cutting tool materials, four metal processing studies, five plastics processing studies, and four studies of materials behavior.

"Engineering Education and Industry"
Frank E. Perkins, MIT
James D. Schoeffler, Case Western Reserve University

Dr. Perkins talked about the education of engineers for industrial careers. (Nothing new or revealing was observed.)

Dr. Schoeffler described the nature of the problem, its implications and recommendations. He cited the Engineering Education Report as a reference.

"Automation for the Job Shop"
Robert T. Lund, MIT

Mr. Lund presented an interesting talk on Computer Modeled Processing Machine Systems (CMPM). He showed that such systems have a place in job shops and production plants and that under many conditions, they can produce parts at a favorable price. He then showed a movie of the automatic processing line that was designed and built by Cincinnati Milacron and Ford Motor Co. This system was very impressive with everything computer controlled from routing the parts to various machines to the complex selection and change of various tools on each machine. (A later discussion with Richard C. Messinger, Vice President of Research, Cincinnati Milacron revealed that this machine had been put into "moth balls", the computer returned to its manufacturer, and that there was really no current interest in encouraging any purchase inquiries for this type of machine system. It was also rumored that the above machine system was offered to MIT if they would keep it operational but that they refused due to its high upkeep cost.)

"Computer-Aided Design"
John J. Allan, III, University of Texas

Dr. Allan presented a colorful slide-talk on computer-aided design; what it is, how it works and the advantages that are derived from its use. He used the system at the University of Texas as his presentation model. The ensuing discussion pointed out that the hardware for such systems is readily available but that huge software development is necessary before the systems can be put to good individual use.

WORKSHOPS

Five different workshops were held to allow more of an expression of opinion from the attendees. Summaries of the discussions in each workshop are included in the section following this report.

The author of this report participated in Workshop A - Industrial Research and Development. The discussions in Workshop A have been significantly toned down as given in Appendix B. It was evident that several problems existed. The facilities, interests, and staff capabilities in universities are largely unknown to industrial management except in a few cases. Industry does not trust academic personnel as good managers of any research projects. Their past experience has shown that university people do not research the problem in question, but are off on a tangent somewhere. When asked to account for their progress, communications are unsatisfactory. Industry feels that University people really don't understand the problems of profit oriented manufacturing companies. It was felt by the industrial representatives that only basic research should be done in universities and that applied research should be done by the industries. The four university personnel in this workshop did not agree with that statement.

QUESTIONS AND OPINIONS

Each of the workshop sessions prepared a number of questions that were then submitted for opinion voting at the end of the conference. The audience at this point was considerably changed from that of the conference due to early departures of industrial people and participation by MIT graduate students. However, the voting did produce some interesting conclusions. The entire tabulation of questions and the voting results are attached.

MIT PROGRAMS

MIT has several programs that provide university-industry interaction. The following are described more fully in the information bulletins included in Appendix F.

The MIT ASSOCIATES PROGRAM has as its purpose to provide member firms direct and convenient access to their educational and research programs while at the same time providing the Institute with important unrestricted financial assistance and professional relationships.

The INDUSTRIAL LIAISON PROGRAM has as its purpose the establishment of stimulating contact and information exchange between the Institute's faculty and representatives from industry.

The ADVANCED STUDY PROGRAM and SELF STUDY PROGRAM are graduate study programs for practicing engineers, scientists, educators, and students.

WORKSHOP DISCUSSION SUMMARIES

The objectives of the workshops were to obtain opinions of the participants on various subjects related to manufacturing and to formulate issues to be presented to the whole conference at the final dinner session. Each group contained a discussion leader and a recorder/reporter. The discussion leader sought to focus the discussion and to identify points of controversy, and the recorders provided this account of the major points covered in the discussions.

Discussion Leaders

Prof. Albert Hopkins
Mr. James Nevins
Prof. Frank Perkins
Mr. Jerry Schaufeld
Prof. Nam Suh
Prof. Daniel Whitney

Recorders

George Foote
David Gossard
Peter Heineman
Scott Holden
Harry Koba
Bruce Kramer

Workshop A Industrial Research and Development

On many of the basic issues discussed in this group there was good agreement both among the industrial participants and between industry and academic personnel. A possible exception was the question of how much university research should be sponsored by industry.

The question of public concern for issues such as pollution, resource conservation, worker health, safety and job satisfaction was discussed. Here the group concensus was that the prevailing public attitude was one of complacence. That people are "happy with the way life is" and have, in general, no intentions of "stirring things up" were two predominant feelings. Industrial concerns continue to be strongly, and probably necessarily, profit-motivated.

Concerning public policy, there was strong sentiment that the declining U.S. economic position relative to other industrial countries is a result of those nations' government subsidy of industrial research and development. Japan, West Germany and Hungary were cited as examples.

It was felt that the U.S. government should sponsor industrial applications research as well as sponsoring university research.

Workshop B Public Policy and Manufacturing

The major focus of the discussions was the involvement of government in the market system both at home and abroad. The feeling that the government served to interfere with the "normal market forces" at home was quite predominant, and it was felt that in most cases, government intervention should be a last resort. It was pointed out that, while the government knew quite a lot about the larger companies in the country, very little feedback was ever received from the medium and small-sized operations. This could help in providing more adequate information on which the government could base its policy decisions.

The second interest of many firms represented at the workshop was the influence of foreign competition. It was thought that the most effective means of facing this matter was to have more information available from government sources concerning the technological advances, business growth, and future trends in foreign industries.

Major questions were raised concerning the standards which the government uses to determine policy regarding industry, the types of response which government should use in a problem area, and the philosophy to be assumed in the present situation of materials shortages.

Workshop C - 1 Productivity Improvement

This group dealt with a variety of levels of productivity, while the participants showed a primary concern with productivity at the level of an individual company or of a particular manufacturing process within a company. This was shown by an informal feedback poll of people's interests, and paralleled by the conference response at the closing session. This was in contrast to the emphasis of the early conference speakers on national, international, and even global productivity issues.

This dichotomy of interests presented some problems in reaching a common definition for discussion. Interestingly, while productivity concerns were uniform across the group of participants, few had an actual productivity measurement program in their plants.

The importance of improving product quality was recognized, but its role in measured productivity was not resolved, and the specter of energy, resource and labor limitations remained in the background of each discussion. Still there emerged a feeling of optimism, perhaps summarized that improvements in productivity would find their reward in the marketplace. These feelings were quantified in the feedback sessions. A number of people felt we would not encounter growth limits to our production (G.N.P.). The view on productivity was even more optimistic, expressing again the optimism cited above, apparently implying that we can produce as much or more using less of our efforts, even if the resource base diminishes.

The role of the university in productivity improvement was discussed. It was felt that in addition to teaching, the university should play an important role in moving ideas into commercial applications by an interest in continuing education and in prototype programs with industry.

Workshop C-2 Productivity Improvement

The discussion in this group focused on two primary questions.

1) How can productivity improvements be effected?
2) What role can federal policy play in bringing about major productivity improvements?

On the first question, there was a strong consensus that strengthening the tie between the manufacturing and design processes should provide substantial and relatively "costless" improvements in productivity and in product quality. It was felt that longer product life and lower costs would be the logical results of these improvements. This posed an interesting question which was later presented to the dinner session: Does the U.S. economy require foreshortened product life to function at its present level? Is longer product life desirable from an economic standpoint? The group consensus was that longer product life was desirable and indeed necessary from global resource considerations. It was felt that the "productivity problem" is not limited to manufacturing, but is distributed throughout the entire production process from design to sales to service. This makes itself felt in increasing "overhead" and "burden" costs.

When the role of federal policy was considered, it was strongly felt that direct development of programs toward proper resource usage is needed. It was also felt that the international trade climate is unbalanced in favor of foreign competitors. The group feeling was that the U.S. should seek to put U.S. firms on equal terms through a combination of international monetary policy, balanced tariffs, and subsidies.

This contrasted with the prevailing group sentiment that government interference in the domestic economy has been, and is, a negative influence. The improper manipulation of wage and price controls, and the resultant distortions of the free market process were felt to be a prime example of actions which resulted in "more harm than good."

Workshop D Education for Industrial Careers

In discussing what training an engineer should have, it soon became evident that among the participants a distinction was made between a "professional engineer" and a "practicing engineer." This "practicing engineer," depending upon the situation, might go under such titles as Production Eng., Manufacturing Eng., Process Eng., or Industrial Engineer. It was generally felt that today's undergraduate curricula are improperly structured for students aspiring to these situations. Currently, rather than graduating with a practical industry oriented background, they graduate with a theory based education intended for the "professional engineer" who will obtain a graduate education. Three possible alternatives to this situation were suggested. First, schools might offer a three year Associate Engineer's degree. Second, an alternate, industry oriented bachelors program might be offered. Or third, the bachelor's degree might be defined as a non-professional degree with orientation toward going directly into industry. Concern was expressed that even those students interested in engineering theory have insufficient industrial exposure. Therefore, as part of the third plan it was proposed that those in the "professional" program ending with Master's or higher degree be required to work for some period in industry in a university supervised program. As an aside it was felt that university faculty also seriously lack industrial experience.

The other topic discussed by the workshop was continuing education. It was generally agreed that the most useful and successful continuing education fell into two catagories.

1. Managerial science and humanities
2. Specifically applicable new technology

Considerable time was spent discussing the problems involved in some particular attempts to implement the latter. In these cases, management was attempting to educate a group of engineers in a new technology. From the business point of view, the most cost-effective way was to hire an expert (from a university) to come in and teach a concentrated course to the engineers in their plant using real problems for their laboratories. Unfortunately this in many ways is in conflict with incentives posed for most university professors. Two primary problems were cited.

1. The physical separation between the campus and the industry.
2. Teaching in industry does not raise a professor's esteem in the eyes of his colleagues.

It was generally concluded that the first problem could be overcome with the proper administrative changes and appropriate economic incentives. The second problem was not as easy. Such solutions as professors teaching in industry while on sabatical were proposed. However, these proposals share a common problem. While the money available to a professor could be increased, the time available to him cannot. Therefore, unless the priorities are changed from the current emphasis on research or at least modified, the second problem seems insoluble.

Lastly it was observed that, in general, when people are much over ten years out of school they start to give up keeping up with the state of the art. As an alternative to this, retraining people in a completely new field was proposed. It was noted that, at least in some cases, while people give up on piecemeal learning, they are still interested and able to start all over again; thus enabling these people to cope with the fast changing technology.

Workshop E Technology Abroad

The consensus was that the United States will always be able to profitably export technology to the rest of the world as long as American firms are able to operate in the context of the free enterprise system. The feeling was expressed that our economic survival depends on our ability to profitably export technology. Those with experience in multinational firms added the caution that foreign concerns are extremely shrewd negotiators and that careful attention to detail is essential in any contract negotiations.

In regard to the question of whether major technical programs, such as the development of computer-integrated manufacturing systems, should be undertaken on a national scale or through international effort, the unanimous feeling was that the United States is not yet ready to enter into a major international program. Clearly, the national program should be developed first. There is presently an urgent need for an organized national effort to develop computer-integrated manufacturing systems in the United States.

In areas of commercial interest, multinational firms are presently transferring foreign technology to the United States much more effectively and extensively than are federal agencies and/or universities. More active attempts by federal agencies to license foreign technological developments for the use of domestic industry (as has been done in the shipbuilding industry) would be helpful and should be encouraged. Universities can help most effectively by keeping industry abreast of promising developments of international research which are of interest but which are not yet developed to the point of commercial use.

VOTING RESULTS

The lively discussions held in the group workshops developed a series of questions which were presented to the whole conference at the final dinner session. The audience, comprised of 37 industrial and 17 academic participants, was polled by an anonymous group polling technique. Each question (or statement) was accompanied by a menu of responses from which to choose. Each member of the audience selected a single response, then the results were electronically recorded and displayed to the audience. The questions and "voting returns" are given below. The number of total responses varied somewhat due to abstentions and no-responses.

WORKSHOP A INDUSTRIAL RESEARCH AND DEVELOPMENT

Question 1: Industry and universities should concentrate on improved methods of communication.

Responses:	Objection / Other	4
	Top Priority	13
	Moderate Priority	25
	Low Priority	8

Question 2: There should be some form of increased emphasis on a national research policy. Such a policy should include increased funding to universities for basic research.

Responses:	Objection / Other	0
	Yes	21
	No	6
	Maybe	4

Question 3: There are indications that there is a problem of job satisfaction among young engineers.

Responses:	Objection / Other	0
	Agree	16
	Disagree	12

Question 4: Universities could serve as a co-ordinating influence to provide for industry cooperation on OSHA, EPA, etc.

			Industry Only
Responses:	Objection / Other	0	0
	Yes, of course	16	7
	Not clear	19	8
	No	14	15

WORKSHOP B PUBLIC POLICY AND MANUFACTURING

Question 1: Our worst problem with regard to public policy and manufacturing is ... (3 choices)

Responses:

	choice I	II	III	Industry Only (I)
Objection / Other	1	1	3	0
Government interferes too much	11	5	5	9
Government doesn't do enough	2	1	2	1
We can't have prosperity without war or crisis	1	4	5	1
Goals of full employment, low interest rate and GNP growth are not compatible	8	10	16	6
Political, social and economic factors impinge on the decision process.	15	18	4	9
We are not disposed, nationally, to establishing "national goals"	7	6	9	4

Question 2: The proper level of government response to productivity problems is

Responses:

Objection / Other	1
Do nothing	4
Provide information (technical assessment)	11
Provide shelters (tariffs)	2
Provide incentives (regulation)	20
Participate directly (Government Labs, R&D)	5
Nationalization of unprofitable or critically necessary industries	2

WORKSHOP B (cont'd)

Question 3: Specific government action toward manufacturing should be

			Industry only
Responses:	Objection / Other	5	4
	Be the resource of last resort	5	4
	Provide international technical and commercial intelligence data	7	5
	Force cost internalization	3	0
	Aid communication among firms	5	4
	Not manipulate the economic environment	9	5
	Replace restraints with rewards (e.g. pollution)	7	6
	Actively promote rising industries	2	2
	Gently discourage falling ones	0	0

WORKSHOP C-1 PRODUCTIVITY IMPROVEMENT

Question 1: At what organizational level should efforts be put to improve productivity?

Responses:

Objection / Other	0
Global	4
National	13
Statewide	3
Industry	8
Company	8
Manufacturing Process	5
Worker	0

Question 2: In what time frame do you see "growth limits"?

Responses:

	In Production (GNP)	In Productivity
Objection / Other	0	0
1 - 5 years	2	0
5 - 20 years	10	10
20 - 50 years	12	4
50 - 100 years	4	2
100 + years	2	6
Never	11	17

WORKSHOP C-2 PRODUCTIVITY IMPROVEMENT

Question 1: Despite its current high standard of living, the U.S. is productive enough to compete in the world market as long as it can operate on equal terms with others with respect to monetary policy, tariffs, and subsidies.

Responses:	Objection / Other	5
	I agree	34
	I disagree	6
	No opinion	0

Question 2: Wages in the U.S. in terms of productivity are

Responses:	Objection / Other	2
	Quite high	11
	Somewhat high	16
	Reasonable	16
	Somewhat low	2
	Quite low	0

Question 3: Could longer product life be accommodated and still maintain a strong American economy?

Responses:	Objection / Other	2
	Yes	37
	No	8

WORKSHOP D EDUCATION FOR INDUSTRIAL CAREERS

Question 1: The Bachelor's Degree should only be a pre-professional degree.

			Industry Only
Responses:	Objection / Other	7	3
	Yes	18	10
	No	22	17

Question 2: Entrance to graduate school should be contingent upon two university-supervised years in industry for the following percentage of graduate students.

			Industry Only
Responses:	Objection / Other	9	6
	0 - 20%	9	4
	20 - 40%	3	1
	40 - 60%	10	9
	60 - 80%	6	4
	80 - 100%	8	5

Question 3: Engineering education has a responsibility to teach two things

1) Transmission of technical information
2) Development of an ethic and human awareness

What fraction of the teaching should be devoted to 1) ?

			Industry Only
Responses:	Objection / Other	1	1
	0 - 20%	2	1
	20 - 40%	5	2
	40 - 60%	16	10
	60 - 80%	18	13
	80 - 100%	4	3

Question 4: Which of the following modes of continuing education is superior?

			Academic Only
Responses:	Objection / Other	2	1
	People from industry returning to the university for a term	15	4
	University staff teaching as consultants in industry without credit	9	2
	University staff teaching in industry as an extension service of the university	17	7
	University staff using their sabbatical to teach in industry	1	1

WORKSHOP E TECHNOLOGY ABROAD

Question 1: Can the U.S. be a profitable exporter of technology? of products? Yes, both as to profitability and continuation as long as the free enterprise system prevails...The world is (must be) our market.

Responses:		Exporter of Technology	Exporter of Products
	Objection / Other	4	4
	I agree	32	35
	I disagree	6	3

Question 2: On major technical programs (computer-integrated manufacturing systems) we are not ready yet for international development.

Responses:	Objection / Other	6
	I agree	27
	I disagree	10

Question 3: It is urgent that we start a national computer-integrated manufacturing program.

Responses:	Objection / Other	4
	I agree	29
	I disagree	9

GENERAL

Question:	What is your current income?	
Responses:	Objection / Other	1
	Less than $5,000	6
	Less than $10,000	2
	Less than $15,000	3
	Less than $20,000	3
	Less than $25,000	4
	Less than $30,000	18
	Less than $40,000	9
	$50,000 or above	4

Question:	I feel	
Responses:	Objection / Other	1
	Fine	22
	O.K.	13
	Fair	2
	Poor	2
	Confused	5
	Intimidated	6

Question:	The U.S. is tending to become more socialistic.	
Responses:	Objection / Other	1
	Yes	31
	No	11
	Undecided	3

Question:	This technique is	
Responses:	Objection / Other	0
	Useful	32
	Not sure	8
	Waste of time	4